JUNE 1941

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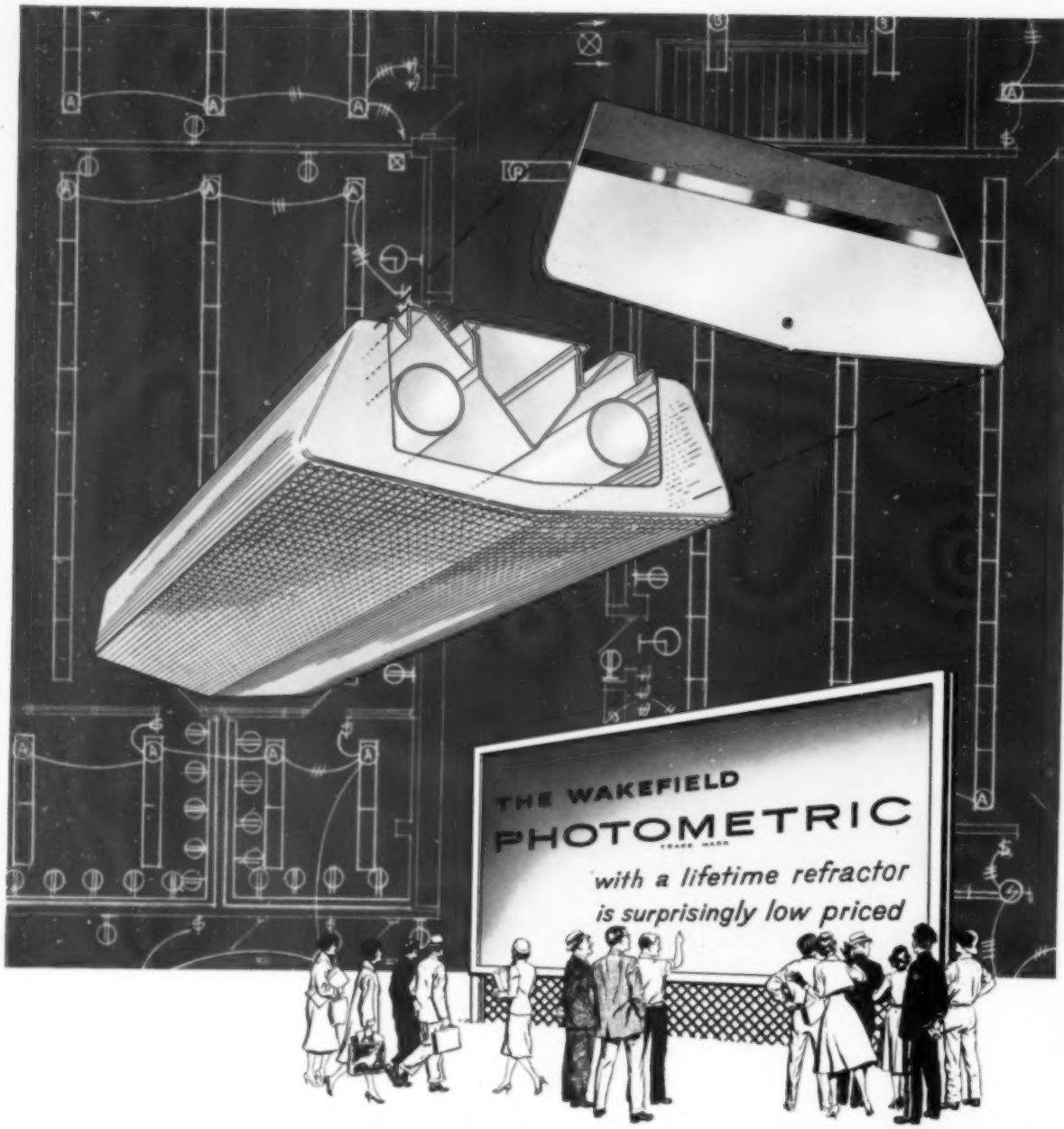
ILLUMINATING ENGINEERING

Journal of the
ILLUMINATING ENGINEERING SOCIETY



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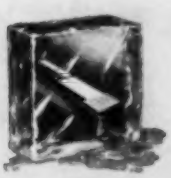

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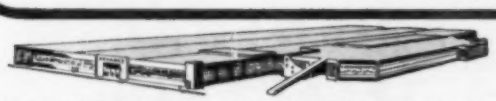

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Listen to the nearsighted Mister Magoo . . . "1959? Seems like last week! I volunteered but the authorities picked seven other Astronauts—and General Electric invented the Quartzline lamp. Happy birthday, Quartzline. Tarnation! This confounded pen won't write!"

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Ask your G-E distributor for more information on Quartzline lamps—small proof of General Electric lighting leadership! General Electric Co., Large Lamp Dept. C-110, Nela Park, Cleveland 12, Ohio.

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THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

June 1961

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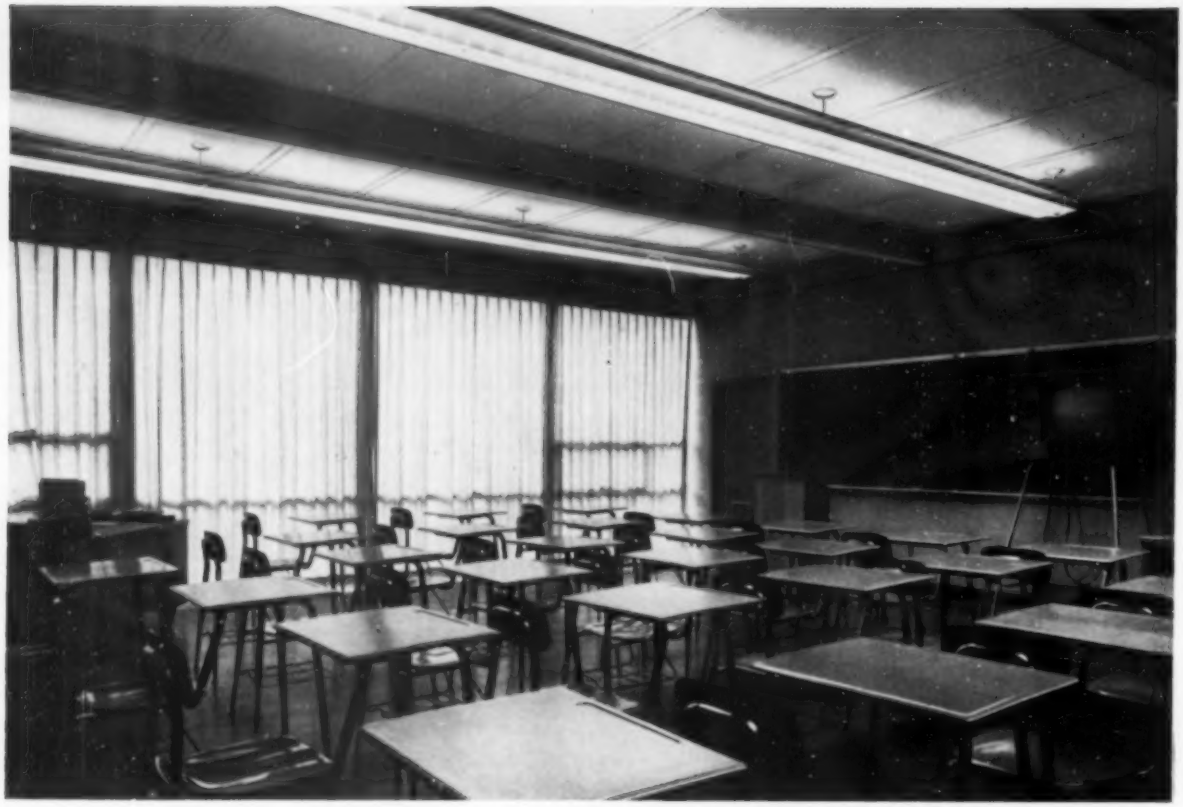

Litecontrol Lighting Helps You See

This is an Award-Winner!

INSTALLATION: Concord-Carlisle High School, Concord, Massachusetts

ARCHITECT: Warren H. Ashley, Hartford, Conn.

ELECTRICAL ENGINEER: Fred Dubin Associates, Hartford, Conn.

ELECTRICAL CONTRACTOR: Delta Electric Service, Boston, Mass.

DISTRIBUTOR: General Electric Supply Company, Boston, Massachusetts

AREA SHOWN: Classroom

FIXTURES: Litecontrol #4628SL and 4624RS, pendant mounted baffle fixtures, on 277 volt operation

CEILING HEIGHT: Approximately 10'-6"

INTENSITY: 50 Footcandles average in service

Winner of a citation for the architect from "School Executive" Magazine, this new, campus type high school is worthy of a second look on many counts — including the lighting. The basic functional fixture design provides every lighting need of this modern school — intensity at today's levels, visual comfort and economy.

The pendant mounted baffle fixtures feature an open top to increase ceiling illumination and facilitate servicing. This type fixture stays cleaner longer and lamps can be changed or cleaned from above. Shielding angle is 45° crosswise. Durable, high quality white enamel provides 89% reflectance.

Litecontrol 4628SL and 4624RS are easy to install, have only 2 parts, no extra parts to assemble.

These fixtures do a functional job for young eyes at this school and for any school where you specify or install them.

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LITECONTROL CORPORATION,

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Ceiling Brightness Control

By KENNETH C. WELCH

RIGHT FROM the start of any knowledge on lighting design and interest in brightness engineering, it was known that diffuse lighting was best for reading. For years, low-brightness overhead lighting naturally decreasing from ceiling to floor has been the engineer's ideal for this task. In striving to achieve it, and still provide suitable levels of light, the catch has been ceiling brightnesses too high for comfort, out of balance brightness ratios and, where diffuse lighting is from an indirect system, either much too little light on the task, or much too bright portions of the ceiling, and frequently both.

For modest budgets, which rule out the ideal luminous ceiling, indirect lighting can be the most feasible method of providing a diffuse system. In addition to possible economic advantages, it can have the virtue of being truly diffuse, truly uniform, completely without shadow. It is akin to the illumination from a clear sky in an open field one minute after sunset—an ideal situation for the two-dimensional seeing task of reading a printed page at approximately arm's length. Further, for two-dimensional tasks of varying surface characteristics, what could be annoying reflected glare is eliminated. A monotonous visual effect, sometimes experienced with ideal diffuse lighting and balanced brightnesses, has been avoided in this installation by an interesting and varied application of color. Some of the wall surfaces are a soft blue-green, others a warm yellow, with background of bookcases and upholstery a

AUTHOR: Fellow, American Institute of Architects, Consulting Planner and Lighting Engineer, Grand Rapids, Mich. Decorative interior design for this installation was by Lila Montgomery Welch, Grand Rapids.

Cantilevered children's room, annexed to Carnegie Library in Sparta, Mich., is built around maple tree landmark. Exterior material of new room is redwood, chosen to harmonize with brick of older building.

General view of room. Varying shades of blue used in geometric color patterns are applied to achieve uniform ceiling brightness. Reflectance of bands ranges from 86 to 46 fL, with darkest band directly above fixture.

deep wine red. Naturally, other systems may be best for other situations: direct light for highlighting; modeling light for three-dimensional tasks; a combination of diffuse and direct for store lighting, etc. For the small library room for children shown here, the aim was to create maximum quality with sufficient quantity of light at minimum cost for initial installation and maintenance as well. This seemed to call for an indirect system and my story is the solution of its one drawback—ceiling brightness control.

The room was an addition to the 43-year-old Carnegie Library in Sparta, Mich., built to honor two Sparta pioneers—my father and my wife's father. Thus, it was a labor of love for us to design its architectural, lighting and decorative plan. This installation in the small town of our birth, dedicated to our own families, provided a source of deep personal satisfaction as well as an opportunity to devise decorative and lighting solutions for a specific problem.

FLUORESCENT LIGHTING

A lighting level of 38 footcandles (in excess of IES recommended practice) is provided by only six 8-foot very-high-output 200-watt fluorescent lamps. These are used in lighting troughs mounted 6 feet 9 inches from the floor. This mounting, which at first flush sounds very low, is in fact very pleasing. The simple design of the troughs, with carefully controlled cutoffs, and especially their color, has been arranged to almost disapear into the visual environment. Ballasts have been located in boxes on the roof.

Very-high-output lamps, one might think, would never be used in indirect lighting troughs if ceiling brightness were to be avoided, and yet they are a source having sufficient light output to give the desired levels in such a system. Low and uniform ceiling brightness has been produced with these lamps, nevertheless.

A system of geometric color patterns applied to the ceiling very successfully achieves both uniform ceiling brightness and uniform lighting levels averaging 36 footcandles. This pattern is in bands of a pleasing blue, varying in reflectance value. The darkest band, of 68 footlamberts, is directly over the fixture, with the other bands ranging from a high of 86 footlamberts (white tile) to 46 footlamberts in the center of the ceiling. This ceiling brightness, though well within the comfort range, produces 38 footlamberts at the top, down to 11 footlamberts at table height. The floor varies from 9 to 20 footlamberts.

The grey table tops have a reflectance of approximately 50 per cent. With about 30 footlamberts on the white paper of the reading material, it can be seen that the brightness ratio between the task and the immediate surround is an ideal 5:1, with the brightest object being the task, as it should be for best concentration.

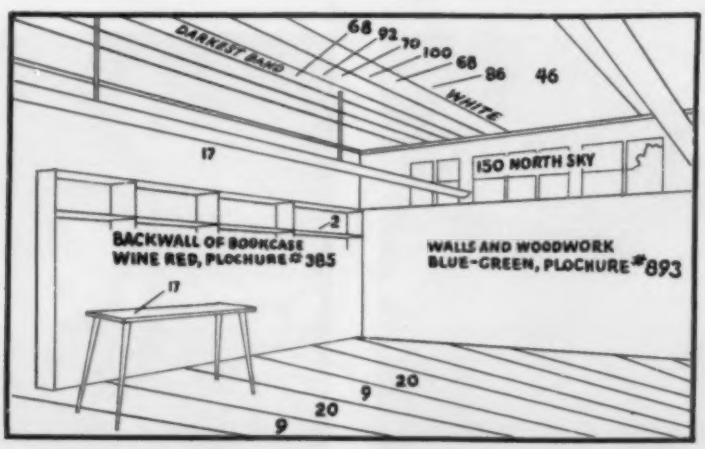
Bay window, designed to preserve maple tree, is fitted with about 50 per cent transmission grey glass to hold window brightness down to an average of 150 fL.

DAYLIGHTING

The new room is designed to make a focal point of a beautiful soft maple 82 inches in diameter, a landmark for generations of children. It is cantilevered out from the old building, over the spreading roots of this maple, and provision is made by the drainage system to supply these roots with the same quantity of natural moisture they have always received. Redwood is used for the exterior material to harmonize with the mellowed old brick. The tree has several bird feeding stations so that youngsters within the library may sit at tables adjacent to the window and see and feed the birds.

To control the north skylight through the high north windows produced by this design, low-transmission grey glass (about 50 per cent transmission) has been used. This holds the brightness of this surface down to an average of 150 foot-lamberts, at the same time retaining the pleasing psychological effect of the window area. Brightness ratio between task and brightest part of the window is 5:1; between floor and task it is 3:1.

The dedication ceremony presenting this new room to the children of Sparta was one of the highlights of my year. Science and art have combined in its design to a delightful conclusion. Known principles of an important two-part lighting formula involving both quality and quantity have proved themselves once again in this stimulating yet visually comfortable library room. Introducing these happy lighting and decorative effects to a room which honors our own families was especially satisfying.



View showing footlambert readings. Lighting level in center of room 34 inches from floor is 40 fc. Level on surface of table is 33 fc. Plochure numbers of blue ceiling bands are 812, 814 and 816. White ceiling band has reflectance of 90 per cent. Floor is yellow and grey.

From this . . .

to this . . .

Classroom condition to 120 footcandles with teaching center highlighted from adjustable spots and floods.

Rearrangement of furniture and light pattern can be flexible to large or small conferences.

For lecture condition—60 footcandles in center of room for note taking; 250 footcandles on stage.

Some 40 lighting patterns are available by means of remote control, and flexibility of lighting design.

Combination Conference and Training Room

Bridgeport Brass Company, Personnel Building, Indianapolis, Ind. Lighting Designer: Paul E. Kimball, Indianapolis Power and Light. Lighting Equipment: Air-handling fluorescent recessed luminaires, 4 feet by 2 feet, using four 40-watt T12 RS lamps, clear plastic low-brightness lens.

Suspended mounted 8-foot fluorescent luminaires for two 96T12 warm white lamps with top reflectors, plastic low-brightness lens.

Suspended mounted 4-foot fluorescent luminaires for four 40-watt T12 RS lamps with top reflectors, plastic low-brightness lens.

Recessed incandescent downlights with adjustable gimbal ring for controlling direction of light 0° to 35° from vertical, 0° to 36° horizontal.

Recessed incandescent fixed downlights for one PAR 38 or R40 floodlight, with 3½-inch opening.

◀LIGHTING

◀HEATING

◀COOLING

Multi-Purpose Ceiling

In its own quiet way, the installation on on the opposite page demonstrates one of the most exciting things to happen to building interiors in this decade. At first glance it looks like an excellent but regular lighting installation, and if it were to have any special interest it would be its remarkable metamorphosis from the garage area (see photo) it once was.

The real story lies in the ceiling. Here is installed all of the services needed for the comfort requirements of over 100 people during several hours of concentrated training—or a small meeting of ten: lighting—of different characteristics and different levels for numerous effects and needs; heating and air-conditioning—both handled through the luminaires; acoustics—public address system—flexibility of room use—all planned into the ceiling.

Its design stems from a five-man planning conference of lighting engineer, heating and air conditioning engineer, ceiling contractor, floor contractor and general contractor.

Starting point of the plan was the lighting, designed to provide a variety of levels and effects through a remote push-button switching arrangement which controls some 40 different illumination patterns. This flexibility of lighting arrangements provides suitable conditions for a wide variety of functions, from small meetings to large training program classes. Lighting in the center of the room can be built up from 60 to 160 fc; fluorescent stage lighting can build to 250 fc; general "office" conditions are designed for 120 fc.

Accepted criteria for all reflectances, by all five planners was the Third Edition, *IES Lighting Handbook*. The generally accepted color was a 64 per cent RF green, with white (85 per cent RF) ceiling and light (20 per cent RF) floor. The result is a pleasing "shade-of-tree" effect.

Having established the lighting plan and system, next studied was the problem of air handling, for both heating and cooling. In this reconstructed area the control of air speed in cubic feet per minute to quiet the air conditioning had to be determined. The objective here was, of course, minimum draft and noise.

Air handling fixtures provide both heat and air-conditioning, as needed. For light control, a low brightness plastic has been used for shielding, and the layout has been planned to take advantage of maximum interflectance.

The photographs belie the complexity of the design problems—and the success of the room. Every need for numerous types of meetings is successfully met by some variety of this one installation—from high level executive conferences to large civic club gatherings.

Can a city mall cure downtown doldrums? Miami Beach believed it could and built this beautiful eight-block long tourist attraction to prove it.

City Mall— key to downtown Miami

THE AMERICAN metropolis, suffering from the decade-long exodus to the suburbs has begun to fight back for economic and cultural survival. President Kennedy's recent proposal for a cabinet-level Department of Urban Affairs gives national prominence to the urban renewal programs which have been burgeoning at the local level for the past few years. These downtown revitalization projects have done much to lure business back to the metropolitan centers.

One of the techniques applied for downtown revival has been the construction of a city mall—a pedestrian oasis offering both scenic and shopping attractions. Famous Lincoln Road in Miami Beach, long renowned for its elegant shops, suffered a drastic decline in business following the area's post-war boom of "fabulous" hotels. These self-contained cities within cities, offering the tourist complete shopping facilities at his door, made downtown excursions infrequent. To compete with these modern hotel shopping facilities, the Lincoln Road Progress Association spearheaded the construction of a beautiful tourist attraction in the center of the city—an eight-block long promenade with lush tropical foliage, pools, fountains and exhibit areas which extends through all but the two end blocks of the shopping area.

Each of the eight blocks, designed by Morris Lapidus, has its own distinctive architectural design, but all are coordinated through the repetition of similar design elements. The lighting, planned to blanket the area, plays a substantial role in achieving *nighttime* unification of the mall. By applying a stage lighting technique, which places the greatest concentration of illumination in the central area and allows the light to bleed off at the sides, lighting consultant Abe Feder has drawn attention to the mall area and effectively separated it from the surrounding city.

General Lighting

Over-all objective of the mall lighting was to create a blanket of light, rising as high as possible, to produce a three-dimensional unity within the area and provide the security of daylight. Lighting accents on plants, fountains and shelters (exhibit areas) were planned to reinforce the architectural motifs.

Since Miami is located in the hurricane belt, maximum permissible pole height for mounting the general lighting units was 60 feet. Eleven tapered aluminum poles, arranged on approximately 250-foot centers down the center of the mall, are used as standards for the general lighting. Three of the poles are equipped with six luminaires each and eight poles with four luminaires. The luminaire is an R80 1000-watt mercury lamp with its own built-in metal reflector housed in a specular Alzak alumi-

Beach revival?

num reflector. The lamp projects a controlled beam of light with an initial output of 53,500 lumens. Comparatively little of this output is lost during lamp life. The specially designed reflector permits further control and intensification of the beam and reduces the amount of spill light.

This general lighting is designed for both illumination and dramatic impact. Light is aimed to accent the tops of trees so that the height of the blanket of illumination is always emphasized. A typical dramatic effect is achieved by targetting a beam of light through a tall palm tree and onto a bed of white flowers below. One interesting economic sidelight of this high-level general illumination system is that it requires considerably less power than the lower-level lower-mounted standard street lighting system which it replaced.

Shelters

Nine low concrete forms, called shelters, constructed to supply exhibit space on the mall are open structures, separated from the exterior only by their roofs. The lighting used in these areas had to blend with the color of the general mercury illumination and at the same time provide good color rendition for display materials. Natural fluorescent lamps which appear cool to the eye but have color rendering properties similar to those of warm white deluxe fluorescent are used in six of

Four underwater spots are aimed at underside of shelter shelf (above) so light washes down along white sides. Indirect fluorescent troffers (below), mounted like rungs between shelter columns, form part of architectural design.

Cascade of water running through a rock garden is highlighted from PAR64 incandescent underwater fixtures set within each shelf. This is one of ten water forms on the mall, each of which is lighted with one of three color tints—blue, blue-green or orange.

the shelters. Extra-high-output lamps of three-, four-, six- and eight-foot lengths are housed in extruded aluminum indirect reflector troffers, mounted from the wall like spokes as part of the architectural design. The light produced bathes the ceilings of the shelters and washes down into the exhibit area. Color contrast of the white fluorescent light within the shelters and the greenish mercury light on the roofs is particularly striking.

Two shelters screened from outside view by lush plantings are lighted with incandescent units. One uses cone-shaped, wall-mounted fixtures; the other, ceiling mounted downlights with perforated metal shades which create interesting light patterns on the ceiling.

The ninth shelter has nine R60 400-watt mercury units in special reflector housings, mounted in groups of three in three "pots" on the floor. Light directed at the ceiling bounces back into the display area in dramatic bursts. Tinted hexagonal cell louvers shield these units to minimize glare.

Water Forms

Ten different water forms scattered throughout the length of the eight-block mall—two jet fountains, two mushroom fountains, a waterfall, weir and a double column of water which shoots into the air—are particular tourist highlights. All are lighted with PAR64 incandescent underwater fixtures with special horizontal and vertical adjustments for targetting, and colored Plexiglas filters. After the units were targetted on location they were locked into place and are easily relamped.

Although budget limitations prevented the use of dimming facilities for the underwater lighting, color was used with great success. One of three color tints—blue, blue-green or orange—is used on each of the water forms, providing contrast in color as well as architectural form.

Lawn Display Area

A raised 60- by 20-foot oval in the center of the mall was planned as a site for shows and large exhibits. Its lighting is from two 30-foot aluminum poles, one on each narrow end of the oval, with eight PAR64 units mounted within two aluminum rings on each pole. These units can be aimed at the raised oval or at an adjacent bandstand area for effective spotlighting. Provisions have been made for the use of color filters to intensify the stage lighting effect.

Thirteen flagpoles at each end of the mall are lighted by grade-mounted PAR56 300-watt ball-shaped weatherproof units. Standard grade-mounted PAR38 mercury units scattered throughout the mall provide undertree lighting to emphasize the beautiful tropical foliage.

The visual effect of the illumination design—cascading colored waters, high-mounted lighting playing on the tree tops and flower beds, the blend of interior and exterior lighting which turns the shelters into dark silhouettes—is a dramatic addition to the nighttime appearance of the mall. The entire project, constructed in three months within the original $600,000 bond issue, is expected to provide a tremendous lift for downtown Miami Beach business. However, the final test of its effectiveness will be the year-end ledger balancing.

Designing for a Low-Budget School

By ALFRED A. BINDER
GERARD J. OAKLEY

A successful solution to multi-purpose lighting for multi-purpose schools has been achieved by this team of illuminating engineer and architect. All classrooms meet IES recommendation, while keeping within a modest budget. Gym lighting turns this room into a serviceable area for at least eight other uses.

TIGHT SCHOOL budgets, a bigger bug-a-boo every year, have led to the design of rooms to serve as many purposes as possible. Gymnasiums are not just for sports, and the odd school dance, any more. They are quite frequently multi-purpose areas serving also as auditoriums, study halls, ballrooms, and adult lecture halls.

All this has greatly altered the approach to lighting design. This too must be multi-purpose, while bearing in mind that the architect's creation must dictate the pattern. Correct illumination *enhances* the architecture and does not itself command the spotlight.

St. Francis of Assisi School in Ridgefield Park, New Jersey afforded us an excellent opportunity to apply these convictions. All areas of this low-budget elementary parochial school were interesting, and all are in accordance with newest IES recommendations (*IES Lighting Handbook*, Third Edition). The architectural and lighting solutions for the gymnasium were especially satisfying. One room was designed to be, variously, gymnasium, auditorium, study hall, practice basketball court, exhibition basketball court, wrestling and boxing area, ballroom, theatre, and meeting hall. The Church and P.T.A. also occasionally use the room for processionals and fashion shows.

The room is 68 feet by 80 feet, with three laminated arches 20 feet on center, and rising from a height of 20 feet at the sides to 24 feet in the center for a 165-degree peak. The architect had provided a design perfectly adaptable to the flexible combination of fluorescent lamps and incandescent spot lamps needed for multiple purpose use and illumination. It might be interesting to note that this "hall" is one of the first installations to feature

AUTHORS: Mr. Binder is a lighting consultant of Spring Valley, N. Y., Mr. Oakley, architect for the building, is from Bergenfield, N. J. Color consultant and interior decorator was Mrs. Betty Gavin, Elizabeth, N. J.; mechanical engineers were F. C. Meyer Associates, Rochelle Park, N. J.; fixture design was by American Lighting Corp., Hackensack, N. J.

View of gymnasium ceiling. Note extra-high-output fluorescent units recessed at edges of canopy and 300-watt downlights in center. This lighting combined with baffled downlights distributed throughout the rest of the ceiling can accommodate a variety of activities from boxing matches to dances and theatrical presentations.

extra-high-output (1500-ma) fluorescent lighting for gym use. With this new source, we have been able to provide the quantity of light required at a relatively low operational cost.

The hall is a highly finished space of maple gym floor, vinyl plastic wainscots, acoustical wall treatments and surfaces, and exposed laminated redwood arches with a finished ceiling of fire-resistant acoustical tile which affords a two-hour additional fire protection to the wood roof deck. The center portion of the ceiling is suspended to create cove lighting and accommodates 100 per cent smoke ventilation apparatus also. The Parish Hall accommodates up to 800 people as an auditorium, 600 people at social affairs, and 450 at dinners or breakfasts. The hall is also air conditioned by two 20-ton units which can be flexibly zoned to cool other areas of the building or operate separately for economy.

The end of the hall contains an oak-panelled stage and proscenium wall which features a 20-foot by 60-foot stage, furnished with stage draperies and a practical dimmer and lighting installation. When used as a gym, the hall contains a standard high school contest court, two cross practice courts with facilities for volleyball and minor athletic activities for the lower grades.

The rear wall has corrugated perforated metal baffles finished in a pastel blue. It serves two purposes—acoustics and decoration. On the left are three interesting setback steps spaced equally apart. These take the place of structural columns, are good for chair storage and add a dimension to the room. The lower sections of the right and left walls are covered with a beige vinyl composition board. the upper section with pastel painted exposed cinder blocks.

An analysis of the various uses led to the following required illumination levels:

- Ballroom, meeting room, theatre: 5-25 fc.
- Gymnasium and practice basketball court: 25-50 fc.
- Study hall and practice exhibition basketball court: 50-100 fc.
- Boxing, wrestling area, and runway for fashion shows, localized or focal lighting: 100-150 fc.
- Processional-localized lighting: 75 fc.
- Emergency lighting.

Footcandle levels were only the first step, of course. Brightness ratios, other aspects of quality, control and esthetics were also planned into the design. Finally, since a gymnasium is subject to hard use, durable luminaires, structure and furnishings had to be considered.

Budget for the lighting was very low (approximately $7500) but even so, it was decided that almost half of it would be allocated to the Parish Hall.

For pleasing appearance, recessed lighting seemed advisable. Fire underwriters' specifications permitted only a 12-inch square opening for every 10 square feet. By study and calculation, a center canopy was proposed to house the major luminous units. In collaboration with the architect, a 16-foot wide canopy was developed to run the length of the room. This canopy permitted the installation of two exhaust fans hidden above the canopy to circulate air and remove smoke. The baskets were also recessed into this canopy. Twelve luminaires were developed to be recessed (20 feet on center) at the extreme edges of the canopy. Reflectors in the luminaire were designed to distribute the light uniformly across the entire playing court. Each luminaire contained two cool white 1500-ma 15,000-lumen lamps and one 7500-lumen lamp. These units were shielded by 45-degree by 45-degree louvers internally hinged and with double safety latches to prevent up or down motion. Tests were performed for safety and impact resistance to basketballs. Since the canopy cove edge and the roof left only a six-inch opening for the cove, the cove lights were designed on top of the luminaire with the ballast remote inside the fixtures. The cove lights are cool white deluxe and are dimmer controlled. The installation was simplified with the use of special snap set levelers. These locked the fixture into place, locked the fixture perimeter tiles and leveled the fixture and ceiling. Thus far, the above gave us a flexibility of 2 to 5 footcandles, 25, 50 and 75 footcandles.

Fourteen 300-watt deep Alzak fixtures with a 5¼-inch aperture were placed 12 feet on center in the 16- by 72-foot canopy. These were set in two rows down the entire length, four fixtures per bay. Every other row (a total of eight) was put on an emergency circuit, to be used in case of power failure. These fixtures, in combination with the other six, would provide lighting for processionals. By circuiting the correct units, a boxing or wrestling ring could be illuminated. Provision was made for four 1000-watt additional fixtures to be plugged into a twist lock receptacle for corner illumination.

Twenty-eight baffled downlights with 150-watt R40 lamps were distributed in the ceiling of the gymnasium. These units have a small aperture and very low surface brightness. Three downlights with acid etched, tempered lenses were placed, one to each structural step, on the left. A three-way switch at each end of the room provided a bright passage in darkness and interesting detail in a dimmed room. The stage lighting is adjustable to three different sets at one time, with variations of from 2 to 270 footcandles in each set with indi-

Classroom lighting levels of 100 footcandles at desk level are achieved within recommended brightness ratios and the limitations of the scissors curve through the use of a reverse reflector in the completely plastic-enclosed luminaires.

vidual spotlighting. The auditorium or gymnasium was colorful, exciting and even enchanting, with levels of 1 to 100 footcandles available from the flick of a switch. Forty-five degree cutoff of all sources provided maximum comfort.

Although the most interesting installation to design was this multiple-purpose auditorium-gymnasium-school room, attention is called to the classrooms because their illumination meets and exceeds the standards set by the Illuminating Engineering Society, all within a very modest budget. Although the classrooms were originally budgeted for 50 footcandles, a newly developed luminaire produced 100 footcandles at no increase in cost. This fixture is completely enveloped by plastic, has a prismatic lens bottom with translucent sides. By the use of a reverse reflector developed for the installation at the Guggenheim Museum, an optical train is created. This diffuses the lamp image over the clear lens and projects more light than many open channels. Its brightness ratios conform to IES recommendations and plots of the footlamberts crosswise and lengthwise meet the scissors curve. These luminaires are mounted three rows per room ten feet on center vertical to the pupils for more comfort. Each row is controlled by a switch. The independent switching permits more uniform levels on bright days and as light fades during the day the farthest row from the window can blend with the daylight. Each classroom is equipped with a closed circuit television set.

Our only regret for the installation in the classrooms is for an additional row of luminaires we would like to have mounted horizontally over the blackboard. Such units, had they been used, would have been directed at the board and the source completely shielded from the viewer. The vertical footcandles on the blackboard would then equal the level of illumination at desk level. Again, the gallery units developed for the Guggenheim Museum would serve, and automatic switching preset at desired levels would permit more accurate control of lighting levels. It is unfortunate that the budget did not permit this blackboard lighting. Perhaps some day it will be more readily appreciated that stretching the illumination budget just a trifle might increase the ability to absorb more knowledge—through lighting.

Despite this lack, the modest budget went a long way. In addition to the Parish Hall and individual classrooms described, the lighting design included, within the total lighting budget:

- Decorative lobby with a curving mosaic mural wall washed by a recessed ceiling cove,
- Lighted trophy cases,
- Lavatories skylighted above a lumious ceiling providing a choice of either daylighting or fluorescent lighting,
- Kitchen lighting which compares favorably with the best commercial kitchens,
- Corridors lighted to the proper ratio of room to hall,
- Shower rooms illuminated to 50 footcandles,
- All areas coordinated both as to lighting levels and decorative appearance.

Of additional importance is the lack of an "institutional" appearance in this school. We are convinced that illumination which has been planned by competent illuminating engineers, and planned as diligently as the architecture, can be the perfect adjunct to teaching; sharpening the senses, alerting the individual, and preventing fatigue of both teacher and pupil.

TYPICAL high quality lighting conditions, such as those in final inspection area, are provided by rows of fixtures aimed to direct light onto all surfaces of cars. Levels of 300 footcandles are achieved here with rows of 4-lamp 8-foot, extra-high-output units, 2 feet wide and approximately 6½ inches deep including ballast enclosure. Translucent plastic shielding in stainless steel frames is easily removed for relamping.

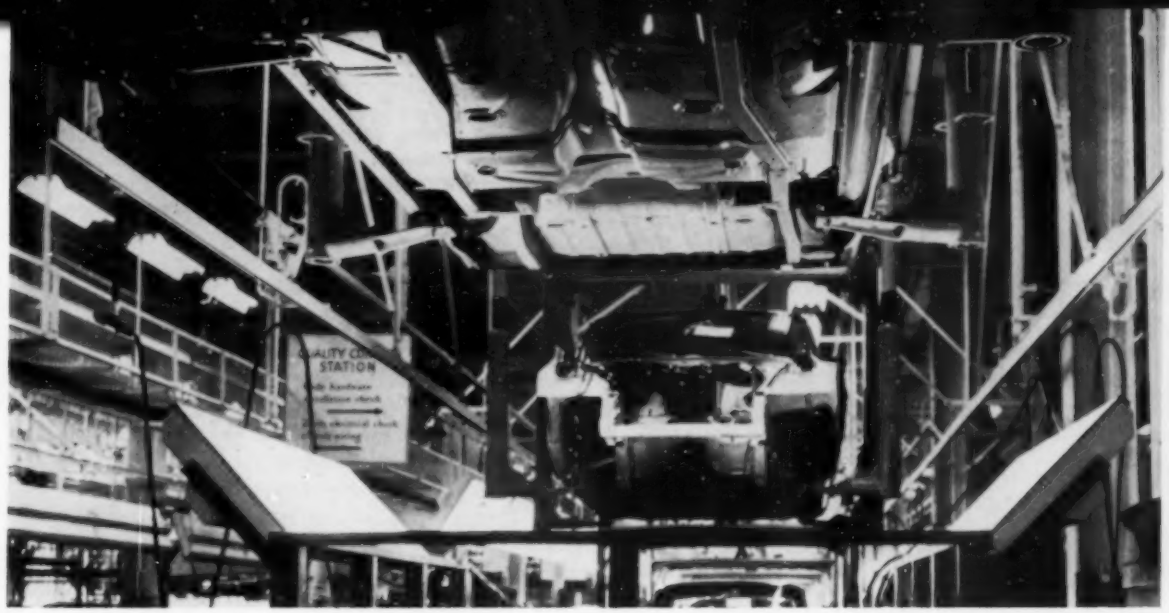
QUALITY < Lighting Workmanship

BUICK Motor Division's new "Special" is aptly named. It is running through an assembly line for special inspection of its special workmanship. Assuring the effectiveness of this inspection is special lighting—high level and high quality—applied for critical seeing tasks. Levels up to 450 footcandles have been uniquely controlled to put plenty of light where it is most needed for quick detection of any defects in workmanship.

Superimposed over the old lighting in a converted press plant, the new illumination system has been designed to be easily rearranged to accomodate further changes in the assembly line operation. Note from the pictures on these pages the interesting inspection techniques which have been worked out by the lighting designers.

Photos and data are courtesy of *Electrified Industry* and Buick Motor Division.

FOR noncritical seeing tasks of mechanical quality check and adjustment, lighting is designed for 100 footcandles. Note shielded units installed on both sides of pit for underbody inspection. Industrial fixtures visible at top of photo are from lighting system of the old press plant.



IN SECTION of assembly line where body conveyor goes up and over inspector (photo above), there are 200 footcandles directed on the underside, of car bodies. Note fixtures in foreground tilted at 45-degree angles.

IN-FLOOR lighting (photo at right) providing 100 footcandles for underbody inspection is from shallow (4½-inch deep) fixtures which were installed without cutting into floor. Note how floor slopes to fixture tops. Good diffusion is obtained from ½-inch plastic shields; ballasts are remotely located on walls or columns.

BODIES entering assembly plant (photo below) are inspected under levels which range from 450 footcandles on body tops to 250 footcandles on floor. Fixtures are suspended from and powered by trolley busway which permits easy rearrangement. In some areas, 2-lamp units are used.

Photo showing three rows of 425-ma equipment in use. The 800-ma fixtures (second and fourth rows) are off in this view. Although light-surfaced desks, walls and floor contribute to the quality of the lighting, the black chalk boards do not conform to IES recommendations.

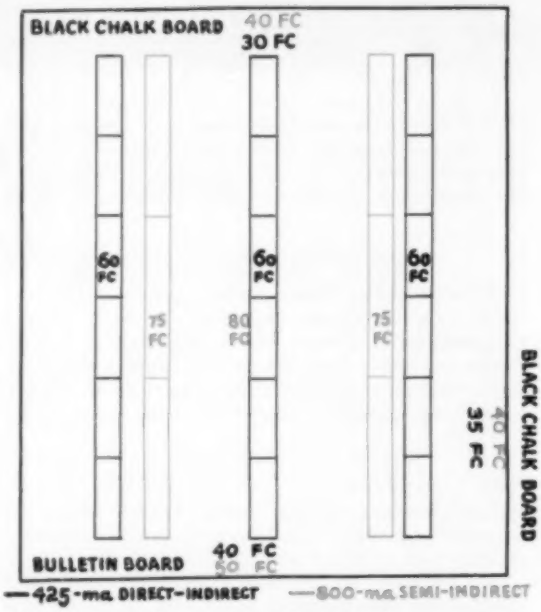
EXPERIMENT . . .
in School Lighting

SINCE COST is so often the determining factor in school lighting, the need for finding the most economical system for delivering quality, high-level lighting to the classroom is one of the most important aspects of this area of application engineering. School lighting designers, perhaps more than any other lighting practitioners, must be prepared to apply the economic advantages of the latest developments in lighting technology.

An interesting experiment for assessing the merits of two kinds of classroom lighting was conducted at the Lancaster, N. Y. High School this year. One classroom, selected as a lighting test laboratory, was used to compare the effectiveness of an illumination system using two rows of 800-ma semi-indirect fixtures with one using three rows of 425-ma direct-indirect units.

To ensure controlled test conditions, the 800-ma units were positioned in an existing 425-ma installation (mounting height, 8 feet, 4 inches) and all fixtures washed and equipped with new lamps. Observations indicated that the systems were equally effective in producing quality lighting—good diffusion and a minimum of glare. The high-output system, however, produced an average of 10 per cent higher illumination (see drawing). Economic comparisons (see table) also favored the 800-ma system. It consumed 11 per cent less power, had a 27 per cent lower equipment cost and similarly lower installation and maintenance costs.

Although lighting designer Harry Sandusky, Sylvania Lighting Products, Buffalo, N. Y., whose 1961 ALC entry this test installation was, declines to draw conclusions from the comparison, it does seem that one of the answers to achieving economical recommended school lighting practice might lie in the use of high-output lamps in the most efficient modern equipment.



Footcandle readings with 425- and 800-ma systems.

Comparison of Classroom Lighting Systems

	3 ROWS, 425-MA DIRECT-INDIRECT	2 ROWS, 800-MA SEMI-INDIRECT
No. of Units	18	6
Load (including ballast loss)	1656 watts	1500 watts
Lamp	F40T12/CW/RS	F96T12/CW/HO
Lamp Lumens	2900	8700
Total Lumens	104,400	104,400
No. of Sockets	72	24
Equipment Cost	$428.58	$313.86
Room Index	E	E
C. U.	.56	.56
Area	24 x 28 feet = 672 square feet	
Ceiling Height	9 feet, 2 inches	
Footcandles	60	60

Progress in Static Converters for High-Frequency Fluorescent Lighting

By W. H. JOHNSON

DESIGNING the illumination for the interior of a building is becoming increasingly complex. A lighting engineer must be familiar not only with light sources and quantity of illumination required for the performance of various visual tasks, but he must also be able to deal with the problems of direct and reflected glare in order to increase worker efficiency, production, and comfort. He must be able to understand the problems of integrating the lighting system with other services provided within the building and be familiar with various electrical distribution systems which may affect economy or efficiency of the lighting system.

Numerous articles and papers have been presented covering the advances in light sources, lighting levels, visual comfort, and more recently, the combination of lighting and other building services. To some extent, the lighting engineer has been exposed to economic comparisons of lighting systems operating from different voltage distribution systems. In addition to the economics of various distribution voltages, the advantages of changing the frequency of the distribution system must be considered. The possibilities of high-frequency distribution systems using static inverters as the power source was initiated two years ago with the development of a 1½-kw transistorized high-frequency converter. The purpose of this paper is to continue the discussion of static inverters, not only from the standpoint of changes in equipment design, but to report on field installations now in existence.

Converter Design

An earlier paper[1] discussed the initial designs for transistorized high-frequency power sources. This first practical converter was rated at 1½ kw output, at 1500 cycles. It provided sufficient power to operate thirty-two 40-watt rapid-start lamps. A pair of lamps was ballasted by a 1500-cycle ballast much smaller and lighter than its 60-cycle counterpart, and having only 25 per cent of the losses of a conventional ballast. This converter was designed primarily for surface mounting. It had heat radiating fins on two sides and was contained in a physical package approximately 20 inches long and 6 inches square. This type of converter has successfully operated an office lighting installation for more than two years.

The success of this converter was due to a unique circuit design using transistors operating in series. Series operation of transistors in this manner and the control of such a large block of power had never before been attempted. As more and more laboratory experience was gained with this type of transistor operation, it soon became apparent that transistors would have to be perfectly matched in order to assure equal voltage distribution between transistors. This matching problem was complex and time consuming and resulted in relatively expensive converters. It was decided that a more practical converter could be developed by using a circuit which would force proper sharing of the voltage among the transistors. Extensive tests resulted in the development of the 3-kw bridge-type converter.[2]

The 3-kw bridge converter has the same input characteristics as its predecessor, the 1½-kw unit, that is, 3-phase, 4-wire, 208-volt, 60-cycle input. Its output is again similar — single-phase, 1500-cycle, but now with a power handling capability of 3 kilowatts. The unit rectifies the incoming 3-phase, a-c power to d-c. This d-c is then pulsed or switched at a rate of 1500 cycles per second by the transistor network, and the resultant single-phase, 300-volt rms square wave of voltage is transmitted at

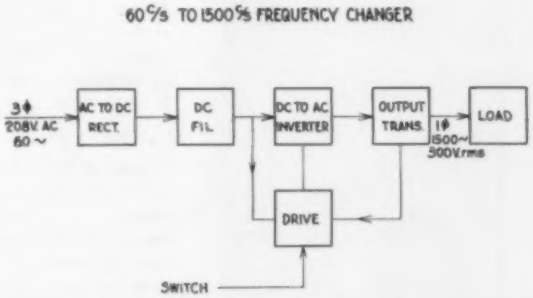


Figure 1. Block diagram of 3-kw transistorized high-frequency converter.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHOR: Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio.

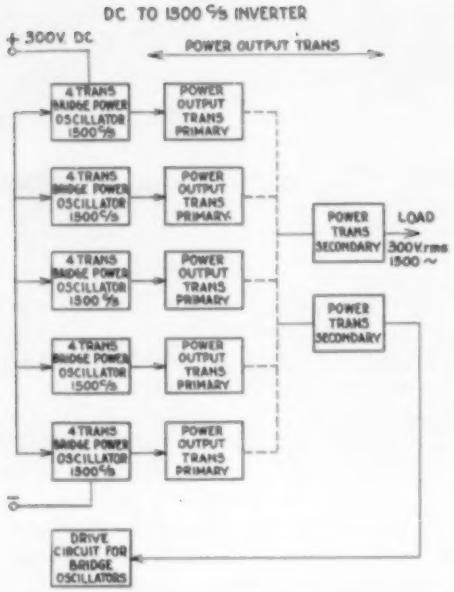


Figure 2. Block diagram of the 3-kw converter showing relation of output transformer to five transistor bridge networks, base drive circuit and output to the load.

1500 cycles to the load. The load consists of fluorescent lamps and their associated ballasting equipment. The lamps may be any of the standard fluorescent lamps available today, but the ballasts are specially designed to operate at 1500 cycles. These ballasts are identical in operation with their 60-cycle counterparts except for the inclusion of a filter network which has the correct cosine impedance variation that allows only fundamental current to flow into the ballast from the square wave voltage source. The major circuit change in this converter is the use of five bridge-type transistor circuits connected in series. The voltage on each transistor is essentially independent of the voltage on any other transistor; therefore, no costly matching procedures are required. The output of each of the five bridges is transformer coupled to a common output winding which serves as the load power source. It is not the purpose of this paper to go into detailed electrical design and circuit techniques as this will be done later in a paper on theory and circuit analysis.

Physically, this 3-kw unit is approximately 18 inches wide, 24 inches high, and about 6 inches deep. This unit is designed for mounting within an enclosure, and has its heat radiating fins all on one side, which should be exposed to the free passage of air. The unit is protected on the input side by a 3-pole, 60-cycle breaker, which also serves as a disconnect for servicing. No output protection is required other than individual fusing of the high-frequency ballasts.

Installations

The first installation of a 3-kw converter was made at the Cleveland Engineering and Scientific Center in September, 1959. This unit has been in constant use since that time and is operating standard 40-watt rapid-start lamps at 1500 cycles in recessed two- by four-foot luminaires. The converter and its lighting load are controlled by a standard 24-volt low voltage control system. A low voltage control system was used in this installation due to the multiple control points required. A second converter installation was installed in January, 1960, in a Cleveland electrical distributor's warehouse. In this installation the luminaires were surface-mounted, and again, used standard 40-watt rapid-start lamps. Control of this installation is by a 60-cycle, 120-volt circuit using a standard switch. Both of these installations are in constant daily operation, and no special precautions are taken in turning these lighting systems on and off.

At the writing of this paper, a third installation

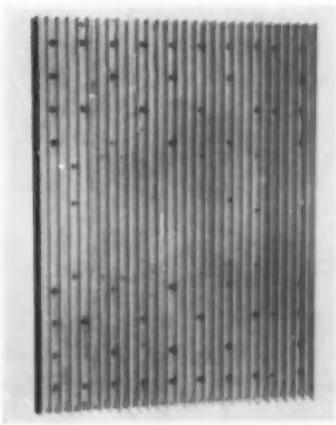


Figure 3 (left). Front of 3-kw converter showing aluminum heat radiating fins. Physical dimensions are approximately 18 inches by 24 inches by 6 inches.

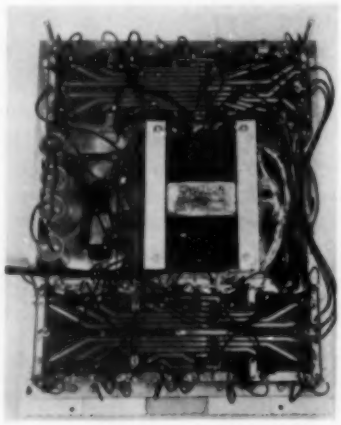


Figure 4 (right). Back of 3-kw converter showing that portion of converter which recesses into cabinet. Extensive use is made of printed circuits. Black box in center of unit is the output transformer.

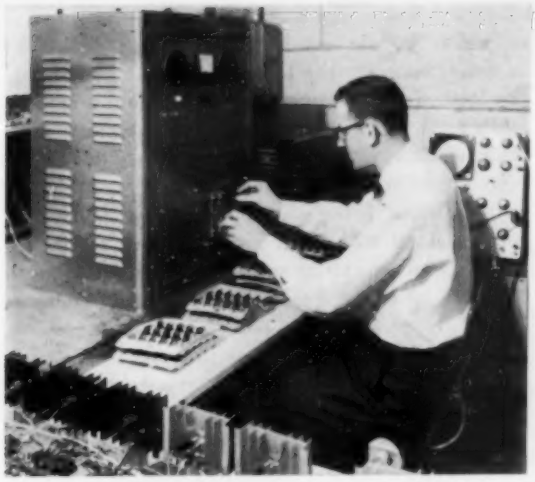


Figure 5. Specially designed test apparatus which is used to check transistor characteristics prior to assembly in 3-kw converters.

Figure 7. Final test of completed 3-kw converter includes electrical characteristic check in addition to operating a full lamp load of sixty-four 40-watt rapid-start lamps.

of 3-kw high-frequency converters is being made at Hamilton City Hall in Hamilton, Ont. This is the largest high-frequency fluorescent lighting installation in the world today. It consists of approximately 150 3-kw converters operating roughly 9600 standard 40-watt, rapid-start lamps.

The general lighting on all eight floors of Hamilton City Hall is provided by high-frequency fluorescent lighting. Each of the floors in the building has an electrical equipment room where the converters serving that floor are rack mounted. Each converter is protected by a 60-cycle breaker and is individually mounted in a perforated metal cabinet. Should a converter ever fail, it is merely necessary to open the input breaker, remove four screws from the converter housing, lift the converter out of its box, disconnect four input terminals and two output terminals, reconnect a spare converter, remount in the cabinet, and close the input breaker. This may be accomplished in a matter of minutes with a minimum of downtime for any small portion of the lighting system, and in turn, permits complete freedom of operation to check and trouble-shoot the failed converter. This not only insures lighting system reliability, but materially reduces any capital investment in stand-by conversion equipment.

Various segments of the lighting system on any floor may be turned on and off by means of wall switches operating 120-volt control relays. This multiple switching permits the operation of only a portion of the lighting system required for after-hour work or weekends, and does not necessitate turning on a large bulk power source merely to operate a few lights. The basic lighting system is a luminous ceiling with lamps mounted above the plastic between two parallel raceways. The high-frequency ballasts are mounted within the raceways and are accessible simply by removing snap-on raceway covers. A unique feature of this high-frequency lighting installation is the automatic switchover to auxiliary generators in the event of main power failure. Certain key converters are wired so that in the event of a power failure, an automatic switching device throws these converters onto an emergency diesel-driven generating set.

The use of high-frequency fluorescent lighting in this building was the result of a number of factors.

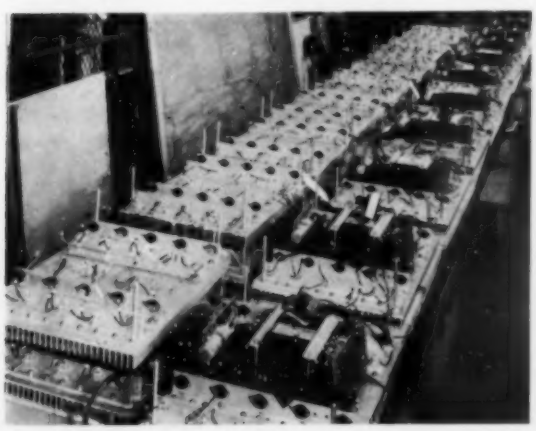


Figure 6. View of 3-kw converter assembly line showing units in various stages of assembly for the Hamilton City Hall installation.

Figure 8. Components of a conventional 60-cycle ballast (at left) and 1500-cycle components (at right). The 1500-cycle ballast utilizes pressed ferrite cores in place of stacked iron laminations, and coils are wound on nylon spools rather than layer wound on paper tubes.

While it was well known that fluorescent lamps increase in light output with high-frequency operation, and that high-frequency ballasts are lighter in weight and far more efficient than 60-cycle ballasts, there were other factors to consider. The size of the building, both in height and in area seemed to preclude the possibility of generating high frequency in bulk quantities at a single location. Furthermore, the transportation of bulk high-frequency power did not seem desirable from the standpoint of increased line losses and other possible distribution problems. System reliability was essential, but it could not be achieved at the expense of large investments in stand-by equipment for bulk-type generators.

These problems were all solved by the compact 3-kw transistorized converter. This permitted conversion equipment to be mounted on each floor thereby minimizing bulk distribution problems, as well as branch circuit transmission losses. The use of the smaller converter package individually serving its associated lighting load also minimized the investment in stand-by equipment required to insure system continuity. High-frequency lamp operation required approximately 10 per cent fewer lamps and ballasts than would have been required for an equal illumination level with a 60-cycle system. Furthermore, the increased light output per lamp plus reduced ballast watts loss resulted in approximately 20 per cent less installed lighting load (in kw) for the high-frequency system than would have been required by a conventional 60-cycle system. This reduced kw of lighting load in the working areas also meant reduced wiring costs and fewer branch circuits. In addition, a 20 per cent reduction in lighting load meant a 20 per cent reduction in air conditioning tonnage required to compensate for the heat generated by the lighting load. In a building the size of Hamilton City Hall, a 20 per cent reduction in air conditioning requirements was considerable.

Not only are newer, more efficient, and higher-output lamps being developed almost daily, but coming along with them are advancements in the technique of operating and controlling these lamps. The transistorized frequency converter of today is constantly reaping the benefits of advancements in the semi-conductor field, and new materials engineering field. As we continue to accept the need for higher illumination levels and to reap the benefits of having these increased lighting levels, we must continue to strive to improve our lighting systems both from the standpoint of initial cost and operating cost. High frequency operation of fluorescent lamps, once considered a lighting curiosity, now seems well on the way to becoming an accepted tool in the hands of an experienced lighting engineer.

The author gratefuly acknowledges the valuable contributions of Messrs. C. H. Burns, J. W. Wigert and J. L. Winpisinger to the work reported here.

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2. Wei, Yin-Min: "Ultra Sonic Frequency Power Generator Using Transistors," *AIEE Transactions on Communications and Electronics*, January, 1960; paper presented at the AIEE Fall General Meeting, October 11-16, Chicago, Ill.

DISCUSSION

G. A. MEYERS:* Mr. Johnson's very interesting paper is a good example of how semi-conductor devices are moving from the laboratory into the field. There they must be judged on their own merits in competition with more conventional distribution systems. At present, high-frequency systems for general lighting purposes are being promoted on the basis of tangible gains in lamp performance and operating cost, as well as more intangible advantages such as novelty, reduction in ballast noise, less loading on the luminaire supporting structure, and presumed savings in air-conditioning load.

Is it correct to assume that 1500 cycles was chosen for optimum converter efficiency? Ballast noise will be at 3000 cycles, the region of maximum ear sensitivity. Is there any noticeable noise in the luminaire from this source? Is the largest area that can be served with one converter determined by limitations on the practical converter size, or by distribution losses?

As the paper illustrates, we are witnessing the emergence of semi-conductor devices as the preferred means of generating high frequencies for lighting. They will progress in cost, efficiency and reliability as fast as the state of the art in semi-conductor technology permits.

*Sylvania Electric Products Inc., Danvers, Mass.

For the engineer who wishes to design and specify a high-frequency lighting system, there is a great need for factual data regarding capital costs, operating expenses, and maintenance of such systems. It is hoped that Mr. Johnson and his associates, as well as other workers in this field, will be able in future papers to discuss performance data and costs of the many installations now operating satisfactorily. When high-frequency systems can instill confidence in their performance and compare favorably in costs to conventional systems, they will rightly have come of age.

E. M. FREEGARD:* The author mentions that various segments of the lighting system in the Hamilton City Hall can be shut off. I assume that this means that each 3-kw inverter can be individually switched. Is it possible to go further and switch off a substantial part of the load of one individual inverter?

Much has been said in the past about the theoretical efficiency of these systems. Can the author quote any figures on 60-cycle input watts per delivered lamp watt?

I believe that there is a continuing need for developmental work on these devices, particularly to reduce costs. To become a major lighting factor, high-frequency equipment must be justified on the basis of an equal or lower cost of light in the normal commercial or industrial installation. Does the author have any prediction as to when costs will be reduced to this point?

During the past several years, noise has become a very critical factor in fluorescent lighting. What has been the author's experience with the noise problem on the high-frequency systems that have been installed?

J. H. CAMPBELL AND Q. D. DOBRAS:** A number of questions have come to mind with respect to the Hamilton installation. The answers will help to provide a more complete technical account of the many components involved.

(1) It is explained that a filter is included in each ballast to correct the square wave of voltage supplied by the converter. What is the resulting lamp current wave form?

(2) Have any lumen maintenance tests been conducted with lamps operating on the power transistor frequency converter?

(3) Does the author consider 1500 cycles to be optimum for branch circuit converters?

(4) What about the economies of the Hamilton City Hall installation; *i.e.*, inverter efficiency, cost/kw, and lamp efficiency? What was the dollar cost saving in air-conditioning equipment? If this installation is a development prototype, when does the author estimate commercial availability of similar units? If 10 per cent fewer lamps are required, does this assume equal wattage? Does the 20 per cent reduction in a-c capacity include losses in the converters?

We cannot agree that high-frequency operation of fluorescent lamps was once considered a lighting curiosity. The first installation, made in 1951 and still in operation today, uses static equipment in the form of two magnetic frequency multipliers providing 10 kw of power at 360 cycles. This practical installation was followed by others totaling well over 1000 kw of 360, 420 and 840 cycles.

We share the author's enthusiasm for the future of high-frequency lighting and believe the use of semi-conductors will permit much wider application of this system. Prototype frequency converters, using both silicon controlled rectifiers and power transistors, now in operation are being tested for use in a number of lighting fields.

We agree with the author that the use of semi-conductors will show certain savings in over-all lighting costs at present footcandle levels, but we would go further in predicting that this lighting tool will be used to provide the considerably higher lighting levels now needed in industrial and commercial applications.

W. H. JOHNSON:* Regarding the question of optimum converter efficiency, the choice of 1500-cycle converter operation was based primarily on two conditions. It was desirable to go as high in frequency as practical in order to gain maximum increase in lamp efficiency and maximum decrease in ballast component size. As frequency goes up, lumen output for a given lamp wattage goes up, and as frequency increases, the reactive components required by the ballast go down in size and also increase in efficiency. To counterbalance this, as frequency increases, line losses for a distribution system also tend to go up. At 1500 cycles it was still practical from the standpoint of distribution to use a pair of wires in metal conduit for runs up to 150 feet. The selection of 1500 cycles was not intended to indicate an optimum converter frequency based either on efficiency of the converter or efficiency of the lamp used.

Regarding Mr. Meyers' discussion, converter size is limited by distribution losses but also, on the practical side, by system flexibility. Larger converters can and probably will be built. However, the larger the converter, the larger the standby equipment required and the tendency to increase length of distribution runs. The original concept of the 3-kw size converter was to offer a system of electrical building blocks offering maximum flexibility and at the same time minimizing line losses due to length of distribution runs.

Mr. Freegard is correct in his assumption that the 3-kw converters installed at Hamilton City Hall can be individually switched. It is not possible at the present time to switch partial loads on a given 3-kw converter. It is possible to switch partial loads from a design standpoint; however, it is not practical from an economic standpoint. With regard to system efficiency, a 1500-cycle high-frequency system is approximately 15 per cent more efficient (based on an efficiency rating of lumens per watt) than a 60-cycle system producing the same illumination level. This 15 per cent increase in system efficiency is made up basically of an eight per cent increase in lumen output of a given lamp and a seven per cent reduction in total wattage based on input watts to the converter.

In answer to Messrs. Campbell and Dobras, the filter included in each ballast changes the square wave of voltage supplied by the converter to a sine wave of voltage, resulting in a lamp current wave form also of sine wave.

Lamp tests with regard to lumen maintenance and life have not yet been completed. Indications are that life is not adversely affected by high-frequency operation and it would appear that lumen maintenance is at least equal to lumen maintenance curves for 60-cycle operation.

A complete story on the Hamilton City Hall installation should be available in the very near future. The 20 per cent reduction in lighting load is based on the lighting wattage installed in a work area and does not take into account the input wattage to the converters. As was explained earlier, system efficiency increases at 1500 cycles due to greater lumen output per lamp at reduced total wattage for the lighting installation.

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*Author.

Fluorescent Lighting for the High-Speed Expressway

By W. J. McCORMICK

METROPOLITAN Montreal, Canada's largest city, has a population of almost 2,000,000 people and is located on an island in the St. Lawrence River. The island is approximately 33 miles long, 9 miles wide and is traversed by a section of the Trans-Canada Highway. The Metropolitan Boulevard now under construction will provide four, and in some areas, six lanes of divided controlled access highway across the island, forming a part of the Trans-Canada Highway and connecting with main North-South traffic arteries, by-passing the main business area. The Metropolitan Boulevard, designed for 55-miles-per-hour traffic with heavy truck transport traffic at night and no pedestrian traffic at any time, is to be completely illuminated when finished in about two years. An approximately seven-mile section, illuminated by about 1900 luminaires, is now in use. The entire 32 miles of the Metropolitan Boulevard, when completed, will be lighted with about 7000 luminaires.

Studies

The consulting engineering firm employed by the Metropolitan Montreal Corporation studied existing lighting systems in both Canada and the United States. Preliminary studies of the various illumination sources eliminated incandescent illumination for the Metropolitan Boulevard, due to the low efficiencies and, hence, greatly increased distribution costs and annual power cost of such a system. Mercury systems could provide economic lighting, but several factors were considered undesirable for this high-speed expressway lighting. Daytime appearance, luminaire brightness, uniformity and driving comfort were some of the factors included in these studies.

This consulting engineering firm participated in the design of the lighting installations for Quebec's recently completed Laurentian Auto-route, where very satisfactory results were obtained with a European design of fluorescent luminaire.

Approximately 1,000 luminaires, employing three lamps per luminaire of the F48T12/CW extra-high-output type, are currently in use on the Autoroute.

Prior to writing the final lighting specifications for Metropolitan Boulevard, an installation of 68 of these European luminaires, which utilize a "sharp cutoff" reflector designed to minimize glare and provide increased utilization, were specified for a Montreal suburb boulevard. Intensities, uniformity, cold weather operation, etc., were evaluated in this installation during the winter of 1958-1959.

The final selection was a fluorescent luminaire with sharp cutoff, utilizing the newer type, 1500-ma fluorescent lamp. The specified luminaire uses two four-foot, 1500-ma, T12 bulb lamps, described in the following condensation of the specifications. Fig. 1 shows a section of the completed Boulevard with the lighting system in operation.

Specifications

The specifications issued on March 16th, 1959, for the lighting equipment for a section of the Metropolitan Boulevard can be condensed as follows:

1. The luminaire will be of aero-dynamic form for pleasing appearance. The contours of the unit will be complementary to the tapering, one-piece steel poles, presenting an over-all artistic design.

2. The spacing and mounting heights will be:

a) Maximum spacing	120 feet
b) Width of roadway (one side)	36 feet
c) Mounting height	32 feet
d) Luminaire tilt	15 degrees
e) Luminaire overhang	2 feet, 6 inches

3. The photometric performance of the luminaire is to be as follows:

a) The luminaire is to confine the light output within a 70-degree cone. Sharp cutoff is to be provided at the 70-degree angle, lamps and reflectors are to be shielded above this angle.

b) An average initial intensity of 1.0 footcandle is to be obtained with only the luminaires on one side of the Boulevard in operation.

c) Uniformity ratios are to be: minimum to average—1 to 3; minimum to maximum—1 to 6.

4. The luminaire will provide a maximum of six square feet wind surface. Material used will not deteriorate in ambient temperatures ranging from minus 40F to 100 F and the luminaire will withstand 100-mile-per-hour winds without deformation or misalignment.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHOR: Sylvania Electric (Canada) Ltd., Montreal, Canada.

Figure 1. Montreal Metropolitan Boulevard Expressway. Photo shows part of completed section with service road and approaches in foreground.

5. The ballast is to provide reliable lamp starting and operation with primary voltages varying from 100 to 130 volts and ambient temperatures varying from minus 20F to 90F.

6. A condensation of the lamp specifications is as follows:

a) The fluorescent lamps will be specifically designed for street lighting. They will be of the 1500-ma, T12 bulb design with a 135-degree internal reflector.

b) The initial luminous flux will be at least 5500 lumens and at least 65 per cent of initial after 5,000 hours of burning.

c) The lamps are to have an economic life of at least 5,000 hours.

d) The maximum light output of the luminaire is to be obtained between 30F and 40F with up to a 25-mile-per-hour wind. The lamps in the specified luminaires are to give not less than 75 per cent of maximum intensity at minus 20F and plus 90F.

Ambient Temperature Conditions

The Montreal climate is generally continental, with warm summers and cold winters, ranging from a July mean temperature of 70F to a January mean temperature of about 15F.[1] The winter season, with mean monthly temperatures below freezing, extends from December to March and is often punctuated by storms from the Atlantic Coast which deposit most of the more than 100 inches of annual snowfall. Montreal also receives frequent cold fronts from the West and North which drop temperatures to well below 0F. The Meteorological Division of Canada's Department of Transport has a weather station at Dorval Airport on Montreal Island and monthly, yearly and long-term temperature and wind statistics are available. The normal extremes of temperatures were covered in the specifications mentioned above, and as the Boulevard is elevated in some areas, wind conditions were also given consideration.

The averages of the monthly minimum temperatures in December, January, February and March are minus 11F, minus 17.2F, minus 15.8F and 0.6F. The average monthly temperatures in December, January, February and March are 17.2F, 15.0F, 17.0F and 28.4F.

It is apparent from the above data that important consideration must be given to operation in these colder temperatures. As the average monthly temperatures are based on a 24-hour period, and we are concerned primarily with a period from approximately 5:00 P.M. to 7:00 A.M., which almost invariably is the coldest period of the day, we can conclude that we are concerned with temperatures in the 0 to 15F range for winter conditions. As will be shown later, the luminaire, designed and equipped with low temperature extra-high-output fluorescent lamps, provides near maximum efficiency in this temperature range. To complete the temperature studies, the warmer summer months were also considered. The warmest period of the year is in late July and early August, with the July-August average monthly maximum temperatures at 89.5F. The average monthly temperatures for July and August are 70.4F and 68.2F.

To further evaluate these temperatures, the maximum temperatures in the 7:00 P.M. to 1:00 A.M. and 1:00 A.M. to 7:00 P.M. periods were studied for the past few years from the *Daily Synoptic* weather records. This study showed that the maximum temperatures during this period of the day were from 70 to 75F. Hence, luminaire performance in the summer need not be designed for temperatures beyond this range.

Wind conditions were considered as to their cooling effect on the luminaires and, hence, effect on light output, but very little more than assumptions can be made. The Weather Station's records

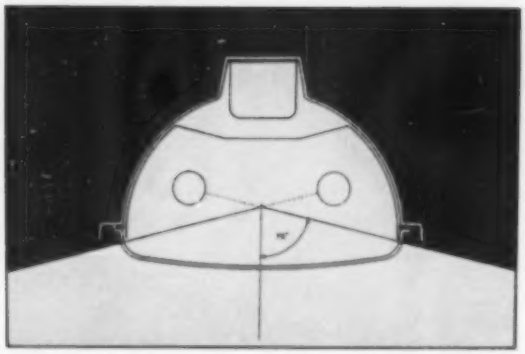

Figure 2. Cross-section of shielded optical luminaire.

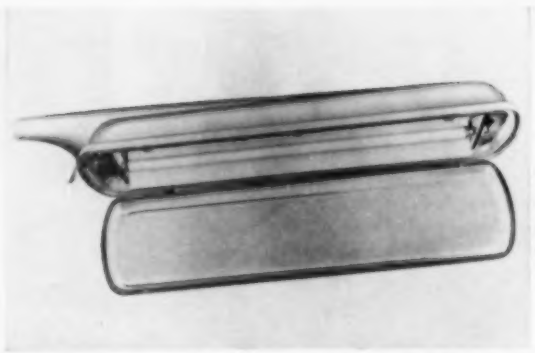

Figure 3. Shielded optical two-lamp fluorescent unit.

show that the wind, in the Montreal area, averaged about 11 miles per hour over the past fifteen years. Wind tunnel tests were not practical and the 25-mile-per-hour wind mentioned in the specifications was assumed to represent a cooling factor of 10F. It is known that previous types of luminaires having large surfaces of plastic exposed to the wind are measurably affected by strong winds. The luminaire for Metropolitan Boulevard presents, for the greater part, a cast aluminum surface which could be less affected by winds.

Luminaire Design

The luminaire selected had the two lamps placed well within the housing, thus confining the light output within an approximately 75-degree cone. This means that light normally emitted above the 75-degree angle—light that is the prime source of glare—is now directed down onto the pavement. The result is an increase in utilization of nearly 30 per cent over that of conventional fluorescent luminaires. The subsequent benefit is more light on the road combined with absence of glare to give the most comfortable seeing conditions possible. The cross-sectional view of the optical system shown in Fig. 2 illustrates how lamps are shielded within the housing to reduce glare. For the Metropolitan Boulevard installation, the reflector lamps were oriented to direct the light into the main luminaire reflectors to provide better distribution. Tests in the actual installation of numerous types of lamps have shown that these reflectors reduce the over-all efficiency, compared to non-reflector T12 lamps, but provide better uniformity. The lamps will be discussed in more detail later.

The luminaire shown in Fig. 3 comprises a one-piece aluminum housing in which are mounted the ballasts, the three aluminum reflectors, four lamp sockets and the slip-fitter clamps for securing the luminaire to the pole. The plastic bowl is cradled in a retaining ring and is hinged on one side of the housing; a single locking lever closes the bowl against foam plastic gaskets which assures a weather-tight seal under all weather conditions.

The prototype luminaire was tested for candlepower distribution, utilization and temperature performance with both regular 1.5-ampere lamps and low-temperature 1.5-ampere lamps. The lamps with 135-degree internal reflectores provided better uniformity with lower luminaire brightness, but produced a reduction in over-all utilization. Part of this loss in efficiency is because the total lumen output from the reflector lamp is approximately 10 per cent lower than the equivalent non-reflector lamp. The consulting engineering firm is at present evaluating the merits of the reflector lamp and if

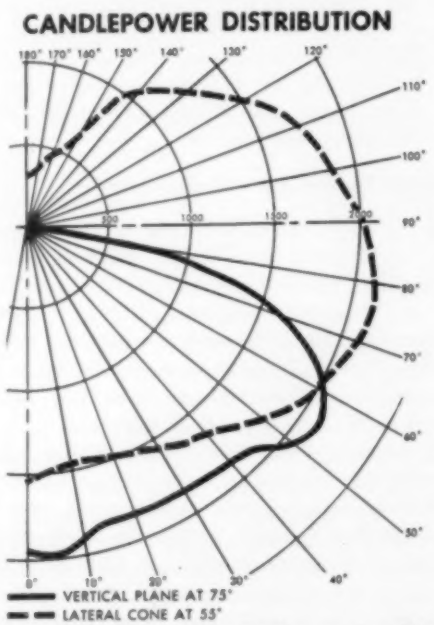

Figure 4. Candlepower distribution curve. Shielded optical luminaire using two F48T12/CW 1.5-ampere extra-high-output lamps.

uniformity and luminaire brightness are considered acceptable without reflector lamps, it is conceivable that relamping next year will be done with the non-reflector lamp. The candlepower distribution curve in Fig. 4 is plotted with two lamps installed. The luminaire is at a 30-foot mounting height and tilted 15 degrees above horizontal; the ambient temperature is 79F. It can be noted that there is no appreciable light above 75 degrees and the high intensity at the 50- to 60-degree angle provides good uniformity. Uniformity data will be discussed later under "Performance Tests."

Earlier in this paper, the ambient temperatures in Montreal, which indicated the need for good cold weather performance, were noted. A prototype model of the luminaire was tested in the laboratories of a lamp manufacturer and a newly designed lamp of the 1500-ma T12 bulb type provided results that would meet the temperature specifications. Further testing with an actual production luminaire at testing laboratories in Toronto verified these results and performance data with both low-temperature and regular 1.5-ampere lamps are shown in Fig. 5.[2]

To be assured of stable test conditions, temperature readings were taken at several spots in the cold chamber, on the luminaire casting, inside the luminaire and immediately adjacent to the lamp. Temperatures ranged from almost minus 60F to 140F, thereby encompassing all possible operating conditions.

The curves in Fig. 5 are shown for still air conditions, and even without shifting the curves to the right some small amount to compensate for the cooling wind effect, the need for the low-temperature lamp is apparent. It should be pointed out that in some areas of Canada, particularly Southern Ontario where winter tempreaures are not as extreme, these luminaires are sold with standard type lamps. However, throughout the Prairie Provinces where winter temperatures are considerably lower than in Montreal, low-temperature lamps will be a necessity for satisfactory operation.

Lamp Design

The extra-high-output 1.5-ampere lamp has been discussed in detail in numerous previous IES papers.[3] The development of lamps with loadings of 25 watts per foot using argon-neon and argon-helium in the smooth T-12 bulb is possible by proper control of mercury vapor pressure. The 1.5-ampere lamp uses pressure control chambers to maintain mercury vapor pressure between the desirable limits of six to ten microns. This design provides maximum light output at the ASA specified temperature of 77F.

Before the introduction of low-temperature lamps, street-lighting luminaires used fluorescent lamps of regular design and maximum light output was obtained when the temperature inside the luminaire was 77F. This frequently meant that luminaires, depending on their design, provided maximum efficiency at temperatures not necessarily corresponding to those predominant in that locality.

In some areas of Canada conventional luminaires and lamps would only provide good efficiencies for the warmer summer months. One design using four of the high-output lamps provided good cool weather characteristics, but severe light output reduction occurred during the summertime.

The larger cubic area of the shielded optical luminaire meant lower ambient temperatures inside the luminaire, therefore lamps designed for maximum output at 77F would not be suitable where cold weather conditions existed. The low-temperature lamp gives maximum output in an ambient temperature of about 30 to 35F, using modified pressure control chambers, and tests show it to be less sensitive to temperature variations than other lamps. Lamps of the low-temperature design are now operating in numerous other installations in Canada and recently about 2000 of these were supplied for other installations in the Montreal area.

Performance Tests

Efficient cold weather operation was certified by laboratory tests as described above and with the

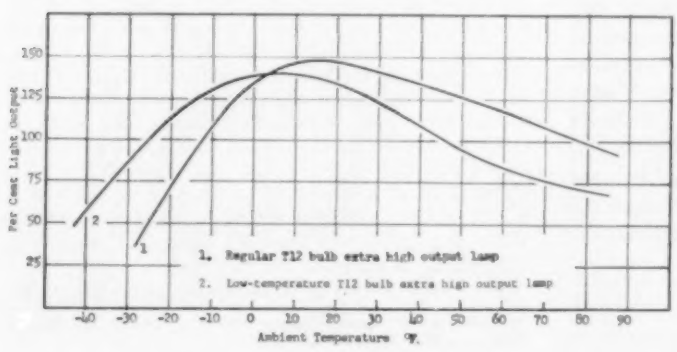

Figure 5. Light output vs. ambient temperature. Shielded optical luminaire performance with two standard 1.5-ampere and two low-temperature 1.5-ampere lamps.

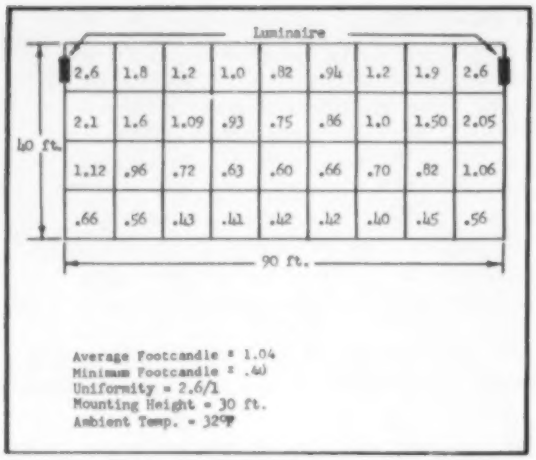

Figure 6. Uniformity test table. Luminaire at 30-foot mounting height gave 1.04 footcandles with uniformity of 2.6 to 1.0. Spacing was 90 feet.

flexibility provided by the availability of two lamp types, almost all extremes of Canadian climatical conditions can be met. Ideally, shielded optical luminaires should be used with 90- to 100-foot spacing to give optimum uniformity and high intensities needed for expressways or heavy traffic routes.

Fig. 6 shows the results of a field test conducted in accordance with IES recommendations, with a 90-foot spacing and 30-foot mounting height; an average illumination of 1.04 footcandles was obtained. A minimum intensity of .40 footcandle with a uniformity ratio of 2.6 to 1 was recorded. Extra-high-output lamps with 6400 lumen rating were used in an ambient temperature of 32F.

Conclusions

Adequate lighting of this new expressway has been provided by giving consideration to all pertinent conditions. In addition to providing adequate illumination, pleasing daytime appearance has been achieved. This shielded optical designed luminaire has been used in other installations and has been modified to a four-lamp unit for parking lots and shopping centers where shielding and optical control have given way to quantity of lighting. Further testing will be conducted on luminaires of slightly different construction by another manufacturer, which are to be installed on the Boulevard in the near future. These units are to provide a similar appearance, but are reported to have a differently designed optical system; subsequent evaluation may be presented in a future paper.

Evaluation of a street-lighting system may be expressed by a quasi-formula:

$$\text{G.L.} = \frac{K \times I \times U}{G}$$

Where G.L. = good lighting
K = constant
I = intensity (fc)
U = uniformity
G = glare

This installation, by giving consideration to all factors in the formula, provides "good lighting."

Acknowledgment

The author is grateful to Mr. W. L. Hawley and Mr. R. Riopelle for permitting their studies to be summarized in parts of this presentation.

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2. Commercial Test Report, No. C1041, Avro Experimental Engineering Laboratories.
3. Bernier, C. J.: "Design Factors of Extra-High-Output Fluorescent Circular Cross-Section Lamps," ILLUMINATING ENGINEERING, Vol. LV, No. 5, p. 282 (May 1960).
Waymouth, J. F., Bitter, F. and Lowry, E. F.: "Factors To Be Considered in the Design of High Output Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. LII, No. 5, p. 257 (May 1957).

DISCUSSION

ALEXANDER LURKIS:* First, I would like to confirm some of the statements made by H. F. Wall in his discussion of the Yaeger-Van Dusen paper, "Factors Affecting the Efficiency of Street Lighting Systems,"[1] in that manufacturers in their test reports present ideal laboratory conditions instead of actual field conditions under which units are used.

Mr. McCormick describes the use of fluorescent lighting for the high-speed expressway in Montreal as part of the Trans-Canada Highway. The matter of greatest interest to me was the use of low-temperature fluorescent lamps. A paper by Karash and Hart[2] discusses this development in some detail. In New York City, we have had a great problem in maintaining fluorescent lamps that were enclosed in exterior jackets, required to maintain operation at a higher temperature for improved efficiency. This improvement will help to eliminate the need for such jackets in areas where the temperature does not get too low, such as New York.

The selection of fluorescent lamps for high-speed expressways is not consistent with what we would do in New York City. Some of the reasons for selection expressed in the paper, based on daytime appearances and uniformity, do not seem to me to be substantial reasons for using fluorescent lamps. I realize that esthetics is a subjective reaction and that what may appeal to some may not be attractive to others. We feel that the appearance of modern mercury luminaires is much more beautiful than the long projecting appearance of fluorescent luminaires. In addition, fluorescent luminaires require closer spacing to obtain the same uniformity and illumination obtained from mercury units.

Our experience has been that fluorescent lamps are more costly to install and maintain in areas where there is no limitation on height. We use fluorescent lighting where low elevation does not permit mercury lighting. With mercury efficiency as high as it is today, with a present life up to 12,000 hours at a maintained efficiency of 86 per cent, I cannot see any justification for the use of fluorescent lamps that have a life of 5000 hours at a maintained efficiency of 65 per cent, as stated for the T-12 lamp.

There are a number of inconsistencies in the paper. The

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required intensity is 1.0 footcandle with a maximum of 120-foot spacing; Fig. 6, however, shows 1.04 footcandles at 90-foot spacing. Therefore, it definitely indicates that the desired 1.0 footcandle cannot be obtained with these units for the specified spacing, especially since this test was made on initial illumination, which would depreciate.

On the one hand it is claimed that the reflectors reduce efficiency, while on the other hand it is claimed that utilization is increased thirty per cent.

The paper states that the desired height is 32 feet, while 30 feet is used in the uniformity test table.

Mr. McCormick claims no glare or lost light in the upper zone for the luminaire used. What happens on tilting the luminaire 15 per cent? In New York City, on expressways of this type, we are using 400-watt mercury, integral modern-styled luminaires—Type III distribution—on approximately 135-foot spacing, to obtain an average of 1.1 footcandles with a uniformity of 3.2 to 1.

I would like to propose to the manufacturers that research be started to show the relation between increased efficiency of a highway and increased lighting.

1. Wall, H. F.: Discussion of "Factors Affecting the Efficiency of Street Lighting Systems, by J. C. Yaeger and H. A. Van Dusen, Jr., ILLUMINATING ENGINEERING, Vol. LVI, No 4, p. 268 (April 1961).
2. Karash, W. J. and Hart, A. L.: "Design and Application of Outdoor Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. LVI, No. 2, p. 106 (February 1961).

W. H. EDMAN:* When I first read this paper, there appeared to be three basic virtues claimed for this fluorescent installation: (1) a new low temperature lamp; (2) luminaire with improved roadway utilization efficiency; and (3) a system with very low glare. However, upon a second reading, I became aware of the fact that the photographs, photometric data and discussion deal with different aspects and there appears to be little or no correlation between these items. This makes it a bit difficult to comment on specific aspects of the installation. However, I would like to make a few general comments.

Apparently the lamps actually installed are of the reflector type, although the photometric data do not relate to this lamp. In addition, the paper deals principally with the development of new low-temperature lamps especially designed for colder climates. Almost half is devoted to the problem of lamp operating temperatures, with the extreme range from summer to coldest winter indicating a high-to-low output of over 2 to 1. Surely this leaves much to be desired when compared to filament and mercury sources which have virtually no ambient temperature problems.

The luminaire improvements that increase roadway utilization efficiency must be most welcome. There is still room for improvement, of course, and the present utilization will have to be almost doubled, when mounted along the side of the roadway, to equal the roadway utilization of available mercury units with much better controlled distribution.

As to the problem of glare, the cutoff luminaire referred to should be much better than the conventional open bare lamp type of unit. It should not be as low in glare as the side of the street-mounted parallel fluorescent units, which are already presently available on the market.

I cannot pass up the opportunity to emphasize again the importance of being more specific when we discuss glare aspects. I am referring to both disability veiling glare and discomfort glare. There is no question that improvements are produced by this luminaire in both discomfort glare and disability glare. However, I cannot agree with the loose interpretation that this unit has absence of glare. Unfortunately, this has become quite a popular way of describing fluorescent luminaires ever since they were introduced. Technical people should be a little more careful in using such all-inclusive descriptive terms. It is bad enough for the layman, who can be excused for not knowing better, but we, at least, should recognize the limitations.

I am wondering about the maintained average footcandle level after the system has been in operation long enough for a lamp replacement, particularly during the summer months and when the lamps are toward the end of life and the luminaires are in need of cleaning. This could fall below 50 per cent of the initial footcandles.

After driving along the Connecticut Turnpike, with 46 miles of mercury and seven miles of fluorescent lighting, one cannot help but realize the desirability of the higher footcandle levels found on the mercury section. The system disability veiling glare is considerably lower on the mercury system and, hence, there is greater visibility distance. As to the discomfort glare effect on a system-wide basis, I have heard many comments that the mercury system is better than the fluorescent. Here, of course, we get into an area of personal opinion. It would be interesting to take a vote of the users as to which system is now preferable after having been installed for almost two years. It will likewise be interesting to see and compare the Montreal installation after it has been in service for a like period of time.

JOHN W. YOUNG:* Appreciation is due the author for presenting the case of a well-conceived lighting project for such an important traffic facility as an expressway. This kind of lighting project presentation should be brought to the attention of the industry more often in the interest of analyzing the design as a sound lighting solution and one that advances effective roadway illumination.

The significant feature of this installation is the sharper shielding of the light source provided by the luminaire to minimize glare. Furthermore, the luminaire optical system design provides increased utilization (for systems using reflectors) compared with past designs. The specifications are quite complete and, without enumerating them, it is clear that attention was given to light distribution properties, electrical and mechanical features, esthetics of the equipment and installation, affording the intensity desired, good uniformity and minimized glare. The low brightness of the luminaire is the outstanding feature in obtaining comfortable seeing in this installation.

Not to depreciate in any way the over-all desirable results of the project, attention is called to the price tag for close spacing of units with cutoff type luminaires. This requirement would apply to other light sources and cutoff luminaires. Lamp spacing is usually a design factor under the control of the application engineer for expressways. The reduction in number of lamp stations per mile is about the only course available in holding down investment and operating costs, and cutoff luminaires at higher mounting and, of course, greater spacing, could still satisfy the quality of illumination desired by the project. Such a spacing-mounting height combination would require a larger lumen capacity luminaire; that is, incorporating larger lamp outputs which, incidentally, would contribute to lowering the unit cost of light production.

It would be of interest to hear of any alternative systems to the 120-foot spacing considered in the preliminary studies. What luminaires and lamp sizes were studied in connection with increasing the footcandle level in the future?

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*Lighting Engineer, Boston, Mass.

A comment might be made on the reference to the trial with a European design of fluorescent luminaire and the selection of the cutoff principle in the unit for the project. Lighting practice abroad uses luminaires employing cutoff at angles as low as 55 to 60 degrees with mercury and sodium sources, as well as fluorescent types that have appeared in recent months. Such design principle contributes importantly to improved visibility and seeing comfort.

HENRY L. WOJCIK:* Serious considerations are being given to the design factors for outdoor fluorescent lamps and luminaires. This is apparent by the current publications pertaining to the recent thermoelectric bulb wall spot cooling development, further improvement of air temperature control in luminaires, and new techniques regarding gas concentration in mixtures at various internal pressures, to mention only a few; all this is an effort to further stabilize the light output of fluorescent lamps as they are subjected to variation in bulb wall temperature. These new developments, improvements and techniques are on the threshold of positive, fluorescent light output designs and sounder understanding of installation economics.

The author stated that an evaluation was made and then specifications were written for the type of equipment that was desired to meet and fulfill the requirements. This brings to point that with the large number of fluorescent roadway lighting installations now in design stages, and those which will continue to be, it is imperative that the many specific requirements of fluorescent lighting equipment and of lighting system design be made known to all who are associated with roadway and other outdoor lighting equipment designs and their application. This should result in a minimum number of types of equipment but incorporating many of the desirable and required features.

Answers to the following questions will be appreciated:

(1) Why was a 32-foot mounting height specified (in specifications) but a 30-foot mounting height accepted (in field test)?

(2) What is the interpretation of mounting height and luminaire overhang for a fluorescent luminaire with 15-degree tilt?

(3) Were monthly minimum temperatures also considered for the period of the day from 5:00 p.m. to 1:00 a.m., not necessarily the coldest for all twelve months, and were nighttime vehicular traffic counts considered for each month to assure highest illumination for the maximum vehicular densities?

(4) What is the minimum average illumination level tolerated on the roadway at any time or period?

W. J. MCCORMICK:** As some of the questions of the discussers are similar, I shall answer them en masse.

Mounting height of the unit is 34 feet on some sections of the Boulevard and 32 feet on others, but in other installations it is usually 30 feet. The luminaire manufacturers' results are given in Fig. 6 as they were used for other evaluations. With 120-foot spacing and 34-foot mounting height, uniformity on the Boulevard was 2.7 to 1.

The mounting height has been taken as the height to the bottom of the plastic bowl at the center of the luminaire. Luminaire overhang in this instance is interpreted (from specifications in French) as the maximum projection beyond the center point where mounting height is measured.

The minimum average illumination that is expected is 0.6 footcandle. This would be with the worst temperature extremes and lamps near the end of their economic life.

Since this paper was written in early 1960, several different luminaire variations have been made commercially available. The cutoff luminaire is available for 6-foot, 1.5-ampere extra-high-output lamps which will permit greater spacing, and more favorable economics, as Mr. Young points out, will likely be needed. The 4-foot luminaire is also available with four 1.5-ampere extra-high-output lamps installed. Some uniformity is sacrificed by this method of increasing intensities, but extremely high quality illumination can still be obtained.

In answer to Mr. Lurkis, the esthetics of a lighting installation are subjective and I cannot agree that mercury luminaires are "much more beautiful," as the smooth tapering shape of the fluorescent luminaire is more complementary to the shape of the pole, the tubular guard rails, etc., than the "lump mass" at the end of a davit or pole presented by a mercury unit. Mr. Lurkis should not base his comments on fluorescent luminaires as they were several years ago, at which time I would have agreed with his statements. As the paper did not present an economic comparison of fluorescent *vs* mercury, I do not propose to lengthen this rebuttal with such. In general (in Canada anyway), fluorescent luminaires compare with equivalent mercury units in initial cost, installation costs would be equal, and fluorescent lamp costs per unit time are lower; admittedly, maintenance cost for cleaning could be higher, but not a substantial amount in the over-all cost of a street lighting installation.

Mr. Lurkis has not read the paper accurately as the maintained efficiency of the lamp is not given as 65 per cent, but as that after 5000 hours of burning. The *at least* 5000 hour life and *at least* 65 per cent of initial lumens at 5000 hours were written early in the development stages of this lamp type. Experience is indicating an economic life of about 8000 hours for these lamps, and the maintained efficiency is also increased.

A reported inconsistency in that reflector lamps reduce efficiency, although 30 per cent increase in utilization is claimed, is the result of incomprehensive reading of the paper. The 30 per cent increase in utilization is attained with a shielded optical luminaire compared to a conventional non-cutoff luminaire. Several other luminaire manufacturers' data confirm this statement. The loss due to reflector lamps is a comparison of reflector *vs* non-reflector lamps in the same luminaire, with an understandable lower intensity but better uniformity and lower luminaire brightness.

Several questions were asked, particularly by Mr. Edman, on the use of the term no-glare. Mr. Edman, I am sure, is aware of the definition in the *IES Lighting Handbook*—glare is brightness within the visual field sufficiently high to cause annoyance, discomfort or loss in visual performance. As there is no objectionable brightness with this system as observed by light specialists and others, I see no reason to refrain from saying that shielded optical luminaires, properly installed, have no glare.

In conclusion, the factors in the expression for good lighting should be given more concern by all of us. Our concern for quantity at the sacrifice of quality can best be summarized by quoting Dr. J. B. de Boer: "Streets in North America are lighted with glare."

I wish to acknowledge Mr. W. L. Hawley's paper, "Look Ma—No Glare," presented at the Canadian Regional Conference in June, 1960. Any inquiries for information about the luminaire should be directed to Mr. Hawley, Powerlite Devices Ltd., 54 Atomic Ave., Toronto, Ont.

*Richardson, Gordon and Associates, Consulting Engineers, Pittsburgh, Pa.
**Author.

INSTALLATION AT TREASURE ISLAND GOLF DRIVE, EL CAMINO REAL AT HICKEY BLVD., SOUTH SAN FRANCISCO, CALIF.

Lighting a Golf Driving Range

LIGHTING OBJECTIVE: To provide illumination for teeing and driving golf balls and for observing the extent of the drive.

GENERAL INFORMATION: This 46-tee golf driving range is a nine- to ten-acre converted vegetable garden. The farthest marker, shown under the house in the photograph above, indicates a drive of 250 yards.

INSTALLATION: An average level of illumination of 10 footcandles is provided at the tees by 35 Westinghouse 16-inch RLM dome units, each equipped with one 200-watt PS-30 lamp. These units are mounted 8 feet apart 10 feet above the tees, as shown in Fig. 3.

The average initial level of illumination ranged from approximately 2 footcandles (horizontal) at 150 yards from the tees to approximately 0.5 footcandle (horizontal) at 250 yards. This is provided by 54 Westinghouse floodlights: 27 AH-16 type 1 weatherproof units (equipped with 1000-watt G-40 clear lamps), and 18 VRC-18 type 3 and nine VRC-18 type 5 weathertight units (equipped with 1500-watt PS-52 clear lamps). These units are mounted on nine steel poles spaced approximately 50 feet apart behind the tees. Each pole has three AH-16 units mounted 29 feet above grade (aimed directly ahead at a point 200 yards out), two VRC-18 type 3 units mounted 27 feet above grade (aimed directly ahead at a point 150 yards out), and one VRC-18 type 5 unit

A.I.A. File No. 31 f

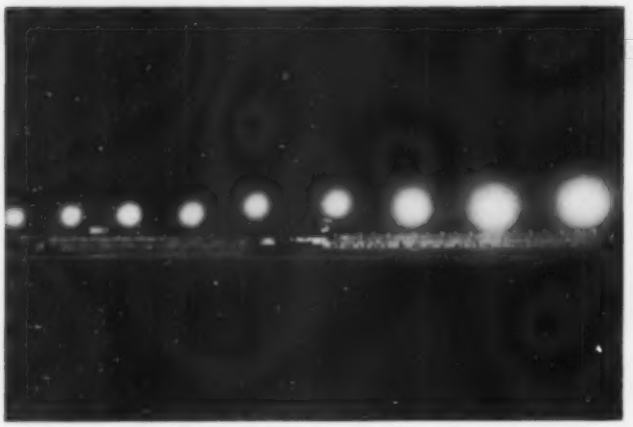

Figure 2 (above). View showing tee locations from 900 feet out.

Figure 3 (right). Close-up of tee locations and two poles.

also mounted at 27 feet above grade (aimed directly ahead at a point 75 yards out), as shown in Fig. 3.

It has been reported that this lighting installation made this range very popular at night, even with two other ranges close by.

Lighting designed by C. M. J. Wood, Pacific Gas and Electric Co., San Francisco, Calif.

Lighting data submitted by C. J. Selby and C. M. J. Wood, Pacific Gas and Electric Co., San Francisco, Calif., as an illustration of good lighting practice and to aid in the design of similar installations.

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Measurement of Visual Information Cues

By H. L. LOGAN
E. BERGER

This paper is intended to furnish some insight into the occurrence of "sameness," which is introduced by the degradation of contrasts by some lighting techniques into some spaces; to explore a possible method by which the subtle differences in degrees of "sameness" introduced by different lighting techniques may be measured and, as a collateral consequence, to call attention to the need for preserving the interest that is inherent in a field of view, and to the importance of lighting so that the operation of the orientation reflex is efficient and certain.

PROGRESS has been made in identifying and measuring some aspects of artificially lighted visual fields, such as minimum lighting levels, direct glare, reflected glare and polarization, but there are other aspects that have so far escaped scientific identification and measurement.

Two identical scenes, for example, can be lighted with different lighting distributions to the same illumination level and can meet the same gross visual comfort criteria; yet, one scene can be clearer and sharper than the other. One scene can convey more visual information than the other, both along the avenue of attention where the data is consciously processed and, perhaps more importantly, below the threshold where it is directed to nonmental terminals (the motor and regulatory systems).

Purpose of Light-Sight Operation

The purpose of the light-sight operation is to gain information of the world external to the observer. As mentioned, this information goes to various terminals in the body, which act upon it. It proceeds from the millions of light receptors in the retina, along their nerve extensions in what can be described as a coded pulsation. If it originates from the neighborhood of the line of sight it goes principally to the higher centers of the brain, where it is consciously processed. If it originates peripherally it goes principally to the motor and regulatory systems of the body, where it influences the observer's objective orientation and adjustment to the space-system in which he finds himself. The effects of this are summated in the organism as a "feeling"—the emotional response of the observer to the effects on him of the visual space.

Recent work by E. L. Gibson and R. D. Walk of Cornell University bears on this. Fig. 1 shows a "kitten standing on a board laid across a sheet of heavy glass set on trestles. The patterned material, which lies directly beneath the glass on the right, is placed several feet below it, giving the appearance of a 'cliff.' Kittens and other animals normally avoid the cliff, descending from the center board onto the 'shallow' rather than the 'deep' side." This despite the fact that they can place their feet on a continuing flat surface and get tactile evidence of the safety of moving beyond the edge of the visual "cliff." "All of the species tested thus far have demonstrated depth perception in this manner as soon as they are old enough to move about, in some cases only one day after birth.

"These observations square with what is known of the life history and ecological niche of each of

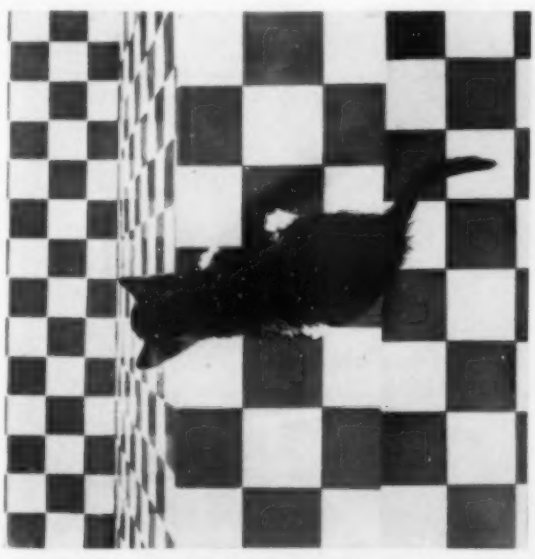


Figure 1. Three-week-old kitten "freezing" at the edge of "visual cliff." (Reprinted by permission of *Scientific American.*)

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHORS: Holophane Co., Inc., New York, N. Y.

the animals tested. The survival of a species requires that its members develop depth perception by the time they take up independent locomotion, whether at one day (the chick and the goat), three to four weeks (the rat and the cat) or six to ten months (the human infant). That such a vital capacity does not depend on possibly fatal accidents in the lives of individuals is consistent with evolutionary theory."[1]

Further, it does not depend upon image recognition, but upon stimuli caused by differential motion of the visual gradients occurring simultaneously at different distances from the observer. "'Motion parallax' causes the pattern elements on the shallow side to move more rapidly across the field of vision when the animal moves its position on the board or moves its head, just as nearby objects seen from a moving car appear to pass by more quickly than distant ones."[2] Present indications are that depth discrimination is not learned, but is innate.

Weakening of Information Cues By Lighting Method

Lighting methods that reduce or suppress visual gradients of the pattern density, or differential "motion parallax" types may provide excellent conditions for intellection based on "two dimensional" work, but result in the "bland" environments so often criticized today. By weakening the differential pattern and motion operations they obscure whatever native interest exists in the field of view, apart from the effect on the emotional tone of the observer.

In short, equal footcandles can, so to speak, be "different"; but traditional photometric methods will not reveal the difference although it may be obvious to the observer. More footcandles may actually reveal less in many cases in which fewer footcandles could reveal more. To take an extreme case, but one that many people have experienced at one time or another, 1,000 footcandles in a daylight fog reveal less useful information than less than one footcandle in moonlight without fog.

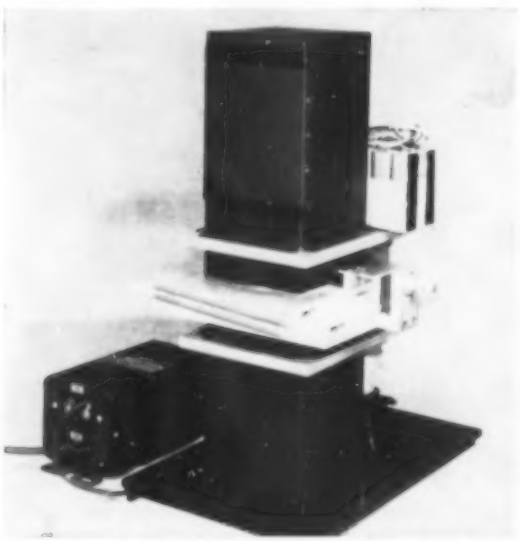


Figure 2. Assembly of picture autocorrelator.

The Concept of Measurement of Information Cues

The field of view can be compared to a television screen. The picture is made up of combinations of dots of differing contrast. The smaller the dots (and so the greater their number), and the smaller the contrast interval between contrast steps (and so the greater *their* number), the clearer the picture, and the greater the quantity of visual information presented to the observer.

As a field of view conveying all the cues for perspective, depth, spatial relations and detail can be constructed in this manner, it can be similarly analyzed and measured for relative information content.

Messrs. E. R. Kretzmer, C. W. Harrison and B. M. Oliver of the Bell Telephone Laboratories investigated this matter, and Mr. Kretzmer developed the Autocorrelator (see Fig. 2), which measures visual autocorrelation.[2]

Autocorrelation

Autocorrelation, as used in this paper, is the average product of the contrast values of each pair of neighboring contrasts relative to the average square of all contrast values, in the scene being measured. It is called autocorrelation because the scene is compared against itself both in coincidence and shifted by regular linear intervals.

The equation for the autocorrelation function used here is derived from the expression for the autocorrelation for a function $F(t)$ of infinite extent along the t axis:

$$\Theta(s) = \lim_{\tau \to \infty} \frac{1}{2\tau} \int_{-\tau}^{+\tau} F(t)\, F(t\,s)\, dt. \qquad (1)$$

where $\Theta(s)$ is the autocorrelation function;
2τ is the aperture interval;
$F(t)$ is direct light transmission;
t is a variable of integration;
s is the shift of the transparencies with respect to each other;

and is shown to be:

$$\Lambda(s) = \frac{(F(t) - \overline{F(t)})\,(F(t\,s) - \overline{F(t)})}{\overline{F^2(t)} - (\overline{F(t)})^2} = \frac{\overline{f(t)f(t\,s)} - (\overline{F(t)})^2}{\overline{F^2(t)} - \overline{(F(t))^2}} \qquad (2)$$

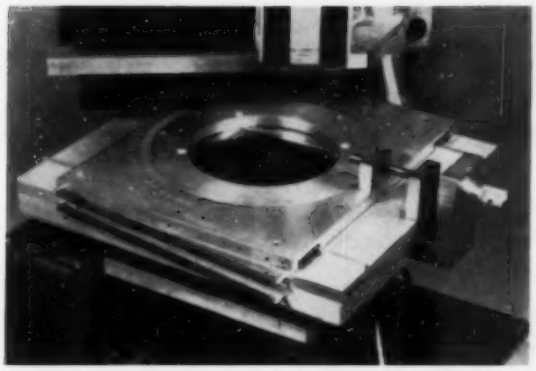


Figure 3. Close-up view of slide holding assembly and shifting mechanism of picture autocorrelator.

where $A(s)$ is the normalized autocorrelation function;
$F(t)$ is the average value of $F(t)$ and is a constant;
$f(t)$ is $F(t)$ with average value removed;
s is the shift;
$F(t)$ is the direct light transmission.

By a simple change of variable $t' = t + s/2$

$$\text{and } A(s) = \frac{f(t' - s/2)\, f(t' + s/2) - \overline{F(t)}^2}{\overline{F^2(t)} - \overline{F(t)}^2}. \quad (3)$$

This equation can be represented directly in terms of light transmission of the scene transparencies as

$$A(s) = \frac{T_2(\pm s/2) - T_1(s/2)\, T_1(-s/2)}{T_2(0) - T^2{}_1(0)} \quad (4)$$

where

$T_1(0)$ = Average light transmission of one picture slide; $T_1(s/2)$ = Same as $T_1(0)$ except the slide has been translated in its own plane by a distance $s/2$; $T_2(0)$ = Average transmission of two identical transparencies in exact register; $T_2(\pm s/2)$ = Same as $T_2(0)$ except that one slide has a displacement $s/2$, the other $-s/2$. The total displacement from exact register is s.

All the T functions should include the variable θ, *i.e.*, $T(s_1, \theta)$ where θ is the angle of rotation of the scene from horizontal. It was found, however, that the autocorrelation function does not show significant differences between θ and 0 degrees for the classes of artificial fields of view checked. It is therefore neglected here.

The values of autocorrelation so obtained permit the construction of autocorrelation curves of, for example, identical scenes using different lighting. A comparison of these curves will then give an implicit indication of the relative volume of information cues revealed by different lighting methods.

Visual Information

Information, being a nonmaterial property of intelligence, is not measurable, but the data from which an intelligence abstracts information may be measured. Visual information depends upon spatio-temporal distributions of luminous radiation. These distributions range from complete uniformity, which is zero pattern, complete redundancy and complete autocorrelation (in which every part of the field predicts all the rest and therefore conveys no information except the existence of the field), to complete nonuniformity, no redundancy, no autocorrelation, in which no element predicts any other and there is a confusion pattern. This investigation's material lies between these extremes.

The observer senses complete visual redundancy as complete sameness, such as the fog example mentioned earlier, or the inside of a featureless sphere. Departures from sameness furnish the cues for visual information. As the degree of wealth of correct information that can be abstracted from a field of view depends upon the degree to which illumination reveals native contrast changes, a measure of the autocorrelation function gives a clue to the relative degree to which these inherent contrast changes are revealed or degraded; in short, it gives a clue to the probable population of contrast cues. The higher the degree of autocorrelation the lower the contrast cue population, and the fewer the data from which information can be abstracted. Con-

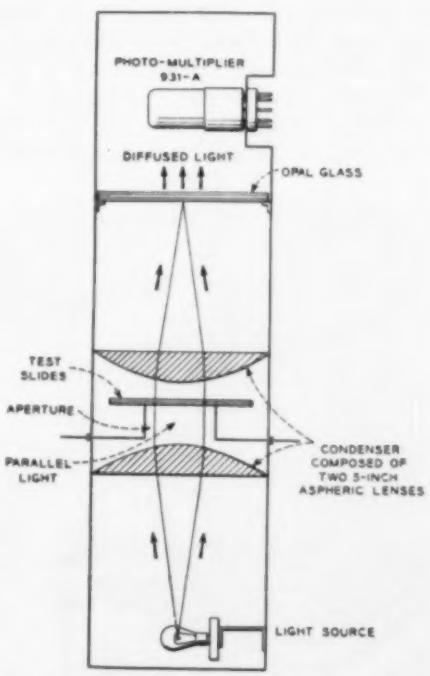


Figure 4. Basic arrangement of picture autocorrelator.

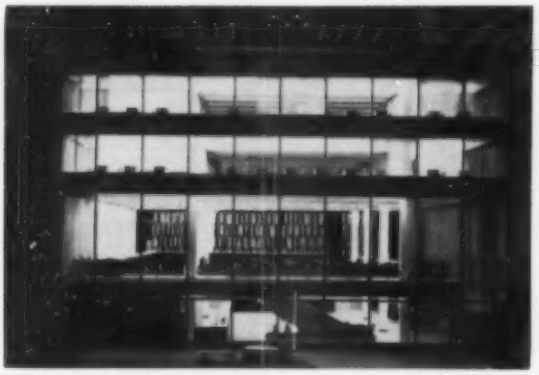


Figure 5. Model showing sharp, clear appearance.

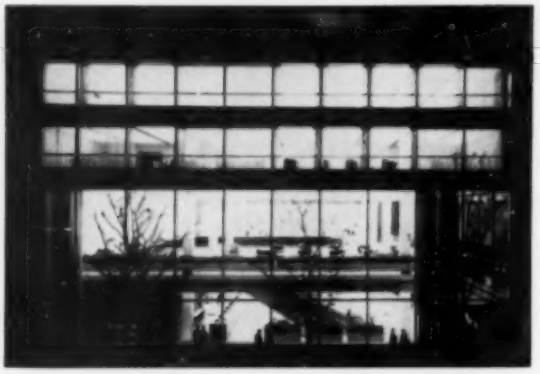


Figure 6. Actual job showing degradation of contrasts.

versely, the lower the autocorrelation, the higher the contrast cue population and the greater the potentialities for abstracting information.

Kretzmer's Autocorrelator

The apparatus devised by Kretzmer to measure the transmission T_1 and T_2, and hence the autocorrelation, is shown in an over-all view in Fig. 2. The most critical component is the mechanical arrangement for holding and shifting the two slides of the picture under study. Fig. 3 shows a close-up view of the table assembly containing the test slides, and Fig. 4 shows a schematic section through the autocorrelator.[2]

Results

Four pairs of identical scenes with different lighting effects are reported here. The first pair of scenes is a bank shown in Figs. 5 and 6. Fig. 6 shows the flattening-out effect, as caught by the camera. This particular picture has been widely publicized and is the same as appears in Kohler and Luckhardt's book *Lighting in Architecture*.[3] The use of the massive screen as a focus of interest at the rear of the principal area serves its purpose well in the model but is hardly visible in the picture of the actual job. The model interior, Fig. 5, is in all respects sharper and clearer. Whether or not the two pictures accurately represent the two scenes is irrelevant at this stage of the investigation. There is no question that this kind of effect exists and has been experienced by most lighting engineers, and the central purpose of this paper is to show that this kind of difference can be measured. Any suitable pair of pictures is appropriate at this stage. At a later stage the technique of securing reliable representations of concrete scenes for the needs of this type of measurement can be discussd. Suffice it for now to point out that the photographic process tends to contract ranges of contrast steps that go beyond the capacity of the emulsion for proportional representation. The result is that scenes with a wide range of contrasts may be under-represented. That is, they may show

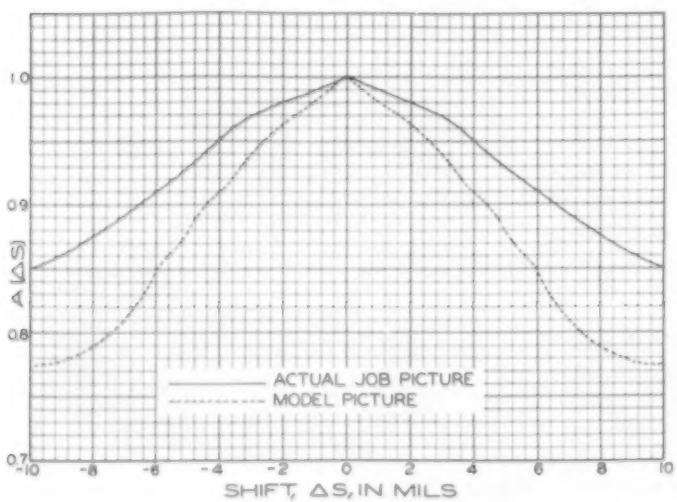


Figure 7. Autocorrelation curves for the two scenes shown in Figs. 5 and 6.

Figure 8. Uncontrolled street lighting.

Figure 9. Controlled street lighting.

a higher degree of autocorrelation in the picture of the scene than in the actual scene. On the other hand, scenes with a small range of contrasts tend to be more accurately represented. The net effect is to show a smaller difference between identical pairs with different lighting effects than between the actual scenes. In short, the nature of the photographic process tends to make measurements of the difference between differently lighted identical scenes conservative.

Fig. 7 shows the difference in autocorrelation between the job picture and the model picture in Figs. 5 and 6. Complete autocorrelation would be shown by a straight line across the top of the diagram at unity. Zero autocorrelation would be shown by a spike rising vertically from zero to the unity line.

Figs. 8 and 9 compare with the same street lighting site under two lighting methods. Fig. 10 gives the autocorrelation difference. The decrease in autocorrelation from Scene 8 to Scene 9 seems to be relatively small and this impression is borne out by a careful inspection of the pictures. Yet the difference in response by the observer is considerable. As he looks down the street in Fig. 8 he is looking into the unknown. As he looks down the same street in Fig. 9 he is looking into the known. A small change in autocorrelation can make a large change in visual interpretation. These road lighting pictures are an excellent example of the large differentiation in response to very slight differences in stimuli that is characteristic of visual interpretation. This will be referred to again later on.

Figs. 11 and 12 compare two identical class-

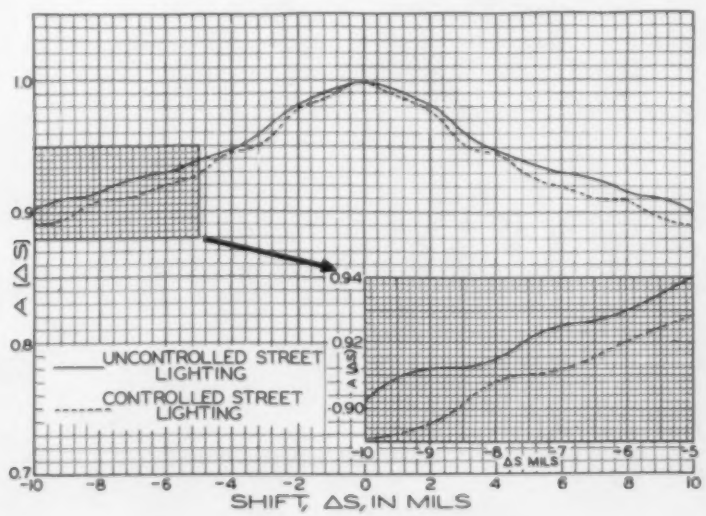


Figure 10. Autocorrelation curves for the two scenes in Figs. 8 and 9.

Figures 11 and 12. Classrooms lighted by indirect incandescent equipment (Fig. 11, left) and semi-direct incandescent equipment (Fig. 12, right). The two classrooms were physically situated side by side, so that it was possible to take both of these photographs simultaneously on the same negative.

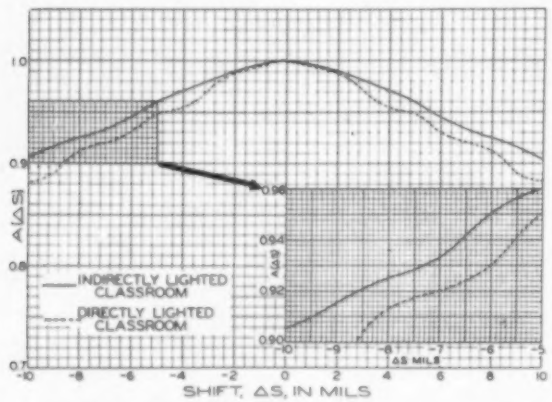
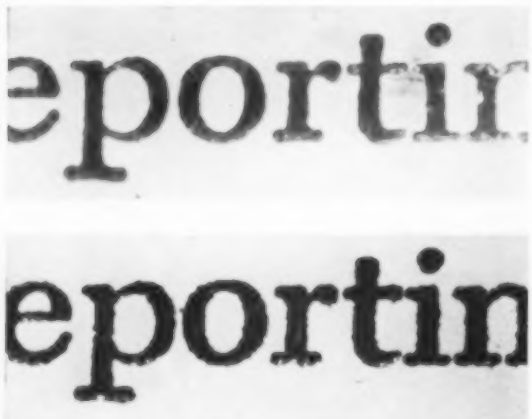


Figure 13. Autocorrelation curves for the two scenes in Figs. 11 and 12.



Figures 14 and 15. "B" of Sample A-1 (Fig. 14, top) and "A" of Sample A-1 (Fig. 15) from "Visibility Measurements on Several Schoolroom Visual Tasks Under Different Lighting Conditions," by D. M. Finch, *Proceedings*, Second Research Symposium, Illuminating Engineering Research Institute, 1958.

rooms as seen from outside, using indirect and semi-direct lighting. The two pictures were taken simultaneously on the same negative, and then cut apart. Fig. 13 gives the autocorrelation curves for these two scenes.

Figs. 14 and 15 give two samples of printed text investigated for reflected glare effects by J. M. Chorlton and H. F. Davidson,[4] and later checked by D. M. Finch. The autocorrelation curves are given in Fig. 16.

So far a conceptual difference in "sameness" has been shown between each pair of members of the four pairs of scenes. What is the degree of difference in sameness, expressed as a number, that these studies show? Here the path is not clear. If the present theory of measurement is followed —the theory that defines measurement as "any precisely specified operation that yields a number" —an arbitrary metric may be adopted, and numbers arrived at; but what would they mean? The

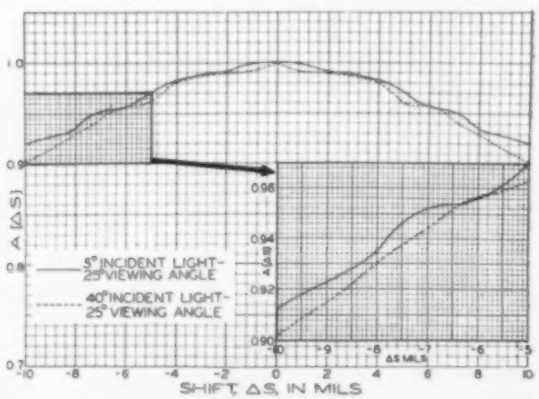


Figure 16. Autocorrelation curves for the two samples of reflected glare phenomena shown in Figs. 14 and 15.

possibility that their full meaning might not be clear, and might have to wait for further data and further insights, is no argument against such numbers. The history of investigation is full of instances where the meaning of the measurements did not become clear until long after adoption; but it is well to understand the present limitations on the meaning of any familiar metric that can be adopted to meet the present situation.

The obvious possibilities are a linear metric, an area metric or a volume metric, but the only thing that can be said with reasonable certainty at this point is that a series of numbers would be generated that were correct sequentially. That is, such numbers would show whether a scene had more or less "sameness" than another scene, but not necessarily how much more or less; just as glare factors show whether or not one scene has more glare than another, but not how much more or less.

The autocorrelation curves give this information on direct inspection so it is not necessary to adopt a numerical expression for this purpose. However, if this kind of data is to have practical, common sense applications, a numerical expression of degrees of difference is necessary; so the authors offer the following, with the sincere hope that others may be inspired to work on this problem and perhaps develop a better solution.

As mentioned earlier, to obtain a complete construct of the autocorrelation function it is necessary to obtain readings for each "angle of rotation of the scene from horizontal," but investigation showed that for the scenes worked with, readings for the lateral shift gave a sufficiently close approximation so that the curves of these readings can be rotated through 360 degrees to generate a volume figure. This volume figure can then be compared to the volume figure for complete autocorrelation, which is the volume of the cylinder generated by rotating the "curve" at unity. The difference can be interpreted as a measure in terms of autocorrelation of the decrease in "sameness" from total "sameness."

The results of applying this metric to the cases studied in this paper are given in Table I.

TABLE I.

Scene	"Sameness"	Difference
Reference Field (Unity Autocorrelation)	10,000 A. C. "Points"	
Figure 5—Actual Bank Scene Figure 6—Model Bank Scene	9,289 8,809	480
Figure 8—Uncontrolled Street Lighting Figure 9—Controlled Street Lighting	9,461 9,380	181
Figure 11—Indirectly Lighted Classroom Figure 12—Semi-Directly Lighted Classroom	9,568 4,447	121
Figure 14—Reflected Glare Sample (5°) Figure 15—Reflected Glare Sample (40°)	9,653 9,594	57

Returning to the earlier statement that a small change in autocorrelation may be followed by a large change in response, the 181 A.C. "points" difference between the street lighting scenes may have greater value to the observer than the 480 points change between the bank lighting pictures.

It is possible that an A.C. change in a scene that is at or near "sameness" may have more value than a similar change in a scene that is far removed from "sameness." It is also possible that the information cue population represented by a change near complete "sameness" is smaller than for the same magnitude change at lesser degrees of "sameness." There is evidence that these two effects occur and may compensate for each other. In that case the metric would be correct for sequence, and may be a good approximation to the actual relative magnitude differences in the degrees of autocorrelation.

The resolution of this will depend upon further work, and further insights into the precise nature of the phenomena related to autocorrelation.

In conclusion, the data from such a few studies can only illustrate the nature of the problem being investigated; but if our present suggestions cannot avoid the incompleteness of a progress report, perhaps they possess the value of opening a perspective, and promising a fuller scrutiny.

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DISCUSSION

B. F. JONES:* There is little doubt that this paper leads into a subject which needs to be pursued and valid coinclusions reached which will improve our control of the seeing environment. The approach that is presented, however, is one with which it is difficult for me to agree. It seems that we are in the position of trying to measure something, but that we are not sure that we are measuring what we wish, nor what the significance of the measurements may be.

It is hard to see how information based on reactions of an immature specimen of a relatively low-intelligence species in an unfamiliar situation can be used to draw valid conclusions regarding the reactions of a mature human being in a familiar environment. There is no doubt that visual information cues form the major basis of our reaction to the physical world, and lack of them, or the presence of contradictory cues, will have a profound influence on our

*Smoot-Holman Co., Inglewood, Calif.

well-being and performance. Anyone who has ever tried to paint the inside of a photometric sphere has had a convincing demonstration of the necessity for visual cues for performance and for orientation. A visit to Cosmos in the Black Hills, or Mystery Spot near San Francisco, as well as numerous fun houses scattered across the country, will give graphic proof of the effects of presenting visual information which is in conflict with other sensory cues. A *Scientific American* article by Herman A. Witkin, "The Perception of the Upright," which appeared in the February, 1959 issue, bears on this problem.

In even a highly bland environment, motion parallax and stereoscopic vision function unchanged. Such an environment, however, does lack interest. I doubt that all the reasons behind such a lack have yet been identified, though the lack of directional flux and its "modeling" effect undoubtedly is a major contributor. There is no reason, however, why the lighting must bear all the blame for the lack of interest. It is quite possible to design a stimulating environment in which the lighting is glareless, from both direct and reflected standpoints. Color, arrangement, texture, construction—all can be used to produce a stimulating or interesting room, free of the "bland" label, even though the lighting is entirely diffuse.

It is also possible to obtain directional flux without introducing glare-producing factors into the installation, thus retaining its modeling effect without the penalty of reflected glare. One way of doing this is to use a substantial directional component along with primarily indirect lighting, with the brightness of the part of the system which produces the directional component controlled so that it does not provide too great a contrast with the ceiling, thus keeping the brigthness ratio low enough to reduce reflected glare to insignificance. Another way is to use an entirely direct system, but one which covers the entire ceiling, and whose brightness is controlled. A ceiling entirely covered with lens panels of the pyramidal or conic element type, above which is either an indirect system or a diffusing panel, will provide the low-brightness variation which makes for successful reflected glare reduction, combined with the high-angle brightness control which eliminates direct glare. In this case, modeling light will be largely retained, since actually all the light is directional light. Note that a luminous ceiling composed entirely of diffusing elements does not meet these criteria and therefore can be a direct glare problem, as well as providing *no* directional flux.

Neither system detailed above will show up well on the autocorrelator if the decoration of the room is not planned to add interest. If the room is decorated to add interest without losing lighting quality, it also may not show up well on the autocorrelator. Since contrast in color, small areas of accent, and shape and texture combinations are the main tools, the gross contrast differences measured by the autocorrelator will not be present.

In short, while I agree that "sameness' in an environment is not stimulating, I am not persuaded that the autocorrelator measurements are at all indicative of interest in an environment, either as to presence or absence, or as to degree. I am disturbed, however, at the possibility that autocorrelator measurements might be used as an indication of quality in a lighting system—a distinction which it cannot claim. Unfortunately, low-quality, high-contrast environments will almost inevitably be rendered as desirable based on autocorrelation points.

I do not wish to imply that this sort of investigation is fruitless. One of the biggest flaws in our current seeing environments, particularly in office and school design, is lack of interest. If the characteristics that go to make up "interest" can be defined and evaluated, a way can be found to measure them. This criterion can then take its place along intensity, brightness ratio, glare index, and the other criteria which must be weighed in the design of the seeing environment for each task.

WARD HARRISON:* It would appear that the increased visual information which the authors are interested in measuring would be of importance in some locations, for example, in street lighting or show window lighting, but would be relatively inconsequential in office and school lighting. A possible exception might be its application to the reflected glare problem treated in Figs. 14 and 15 which, frankly, I do not fully comprehend.

The picture of the cat is intriguing. Would the cat's reaction have been the same if there had been no actual cliff, but simply the change in pattern size on a single plane? As I understand it, the cat had to trust the strength of the plate glass, of which it had no knowledge.

Table I summarizes the results of the authors' computations. The numerical values are obtained by taking the cube of the actual measurements and even then the differences seem small. Their relative order is also somewhat surprising to me. I would have supposed that the street lighting photographs and the reflected glare samples would have rated first and second on the list.

In general, I believe it is the authors' wish to emphasize to us by measurement that a sunny day is more interesting than an overcast day and that we distinguish three-dimensional objects more clearly under the former condition. Further, that totally indirect lighting and luminous ceilings fall into the cloudy day category; there is a good deal to be said for this thesis.

SYLVESTER K. GUTH:* As is usual, many questions arise when any new procedure is presented. The authors do point out that further work is needed in order to obtain a better understanding of autocorrelation. Therefore, perhaps these comments and questions will be added to those which I am sure they already have in mind.

What does autocorrelation indicate? According to the illustrations given, when contrasts within a given scene are relatively low, shifting a pair of such transparencies in the autocorrelation does not produce as much of a change in transmittance as it does in a scene having contrasts. This can be compared with determining how much a photograph can be out of focus so that details cannot be discriminated. Obviously, high contrast will show up better than low contrast. It also seems to be related to the measurement of visibility; that is, how much can a picture be reduced in brightness or in contrast before some of the details are lost?

It does seem that the autocorrelation is rather insensitive. For example, rather small differences in the autocorrelation function are indicated for the pairs of scenes which differ greatly in contrast—street lighting and printed matter. On the other hand, the two views of interior lighting show much greater differences in autocorrelation. These seem to be somewhat contradictory. Furthermore, the evaluation of lighting systems, especially of classrooms, as viewed from outdoors is not considered particularly pertinent. Such

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lighting systems are designed to illuminate things to be viewed by the occupants *within* the room.

According to my understanding of autocorrelation, a better rating would be assigned to a lighting system in which the luminaires stand out in sharp contrast from their surroundings. Thus, a very bright and glaring lighting system could be given a favorable autocorrelation rating. In other words, those aspects of a scene which should be, but are not relatively inconspicuous, are not penalized by the autocorrelator.

I wonder whether "normalizing" the autocorrelation data may result in losing information. Perhaps if the results were presented on some absolute basis, the differences between high and low contrasts would be emphasized.

One very real problem is that a photograph or transparency does not represent a scene exactly as it is seen by the eye. Accordingly, there will be a difference between autocorrelation data and the actual integration of visual contrast sensations. Furthermore, since the autocorrelation function is derived from the average transmittance of pairs of transparencies, no plus factor is given for color contrast. The numerical values merely represent the brightness of the diffusing glass in the autocorrelator as the pair of transparencies is shifted.

A great deal more work needs to be done, not only in photographing and measuring scenes but on the evaluation and analysis of the measurements, before we can be sure that autocorrelation does what the authors of this paper feel it can do.

PHELPS MEAKER:* This is certainly a subject demanding much thought and careful consideration, for there are many pitfalls in a correct evaluation of the procedure and its interpretation. The latter is so important that I want to ask some questions and comment on some points that may bring out more details of this concept. It is realized that the autocorrelator employed for the studies reported in this paper was probably designed for a somewhat different purpose, and that some of its features would have been altered had the authors specified the details of its performance.

Some readers may fail to notice that the total relative movement of the two transparencies (either positive or negative) is only 1/100 of an inch. If the entire view is about three inches wide, this means a motion of only 1/300 of the whole. Accordingly, contrasts evaluated are only between areas that are very close together. In Fig. 5, for instance, the maximum shift is probably a little less than the width of one of the narrower stripes of the screen. Making a conjecture as to the probable photographic distance, it appears that the total shift is a little less than the width of the fovea. A greater shift would be desirable since information is revealed by contrasts with images even beyond the foveal area.

It is noticed that the positive and negative shift traces appear completely symmetrical. It is assumed that relative shift in two directions was useful for the purposes of the original apparatus. It does not appear to add to the appraisal in the present application.

A visual comparison of Fig. 9 with Fig. 8 appears to suggest a way of showing a greater difference than is shown in Fig. 10. If the slides were masked below a horizontal line through the base of the lamp post at the left-hand curve, would there not have been a more significant record? All that light area in the foreground reduces sensitivity, while its margins add practically nothing to information.

The authors say: "Zero autocorrelation would be shown by a spike rising vertically from zero to the unity line." Such a situation would be approximated by a slide which was completely opaque except for a narrow vertical slit one or two mils wide. The record would give only one information cue, but it would be extremely vivid. Hence, very low autocorrelation is not of itself an indication of a large population of information cues.

If a slide were made up of a succession of vertical black-and-white stripes one mil wide, or of a checkerboard pattern of one mil squares, each side of the record would have a series of five peaks and valleys extending from zero to unity. Several thoughts are suggested by this concept. Some qualitative appraisal of the record is needed if one wishes to detect sameness. The slope of the graph seems to be of importance—maybe more than the ordinate values. Since such a record might indicate a high population of information cues, and the area beneath the graph would be about 50 per cent of the area under the unity line, does it follow that maximum information results from a 50 per cent area graph? If so, the interpretation of Table I should take this into account.

The concept of volume metric interpretation is somewhat difficult to visualize. Is this applicable to a scene such as is shown in Figs. 14 and 15, which in actuality would be viewed only over a fraction of 360 degrees?

H. L. LOGAN AND E. BERGER:* Regarding Mr. Jones's comments, the article referred to by Messrs. Gibson and Walk clearly does not confine the investigation to "immature specimens of a relatively low-intelligence species," but covers a wide range, including human infants. One of the aspects of these phenomena is that "intelligence is not involved." The reaction is involuntary and constant. It is operating simultaneously with the voluntary reaction to line-of-sight stimuli, and much faster, as it doesn't have to pass through the delaying mechanism of recognition of data, judgment, decision and finally action.

In short, the kind of optical cues we are principally concerned with are those that trigger innate, involuntary, hereditary mechanisms, with which sentient creatures of all kinds (which possess visual mechanisms) are automatically and continuously dealing, while exposed to visual stimuli. These are the kind of cues that some lighting practices tend to degrade, and for which we have suggested a method of measurement. We agree that the method leaves much to be desired, but we were careful to point out that "the data . . . can only illustrate the nature of the problem being investigated."

Our purpose was to open a way to a method of measurement of the degree to which visual information cues, which affect both voluntary and involuntary responses, could be revealed *by lighting the same scene* by different methods. This has nothing to do directly with the rather ambiguous concept of quality in lighting, but as first things come first, "the purpose of the light-sight operation is to gain information of the world external to the observer." The quality aspects may be added to this primary requirement, to the degree that they assist reception of the necessary visual cues. When added in excess the visual space tends to miscue the observer.

Mr. Jones states with regard to some lighting systems he discusses that "neither system detailed above will show

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up well on the autocorrelator, if the decoration of the room is not planned to add interest." We would like to point out here that there is no criterion of interest as implied by Mr. Jones. Various scenes are merely measured relative to each other. Thus, such a general statement is meaningless.

The general trend of artificial lighting is to develop a closer correlation with the physical, physiological, psychological and esthetic needs of people. This paper is a tentative step toward working out one of the important elements.

With reference to interest, it appears to us that we are not using this term in the same sense as Mr. Jones. He seems to equate interest with attractiveness. We referred to the "native (or inherent) interest" in a scene, and measured the same scene without changing it in any way other than the change involved in lighting it differently. We measured it to see if the instrument selected was sufficiently sensitive to show a difference between different ways of lighting in situations where people could see a difference not interpretable by traditional methods, and we found that it was. We rated this in terms of departure from sameness.

Finally, with suitable color filters, the instrument could operate on colored scenes, but owing to the complexities introduced by color, the first investigation was made with black and white.

We would make a change of emphasis in Dr. Harrison's first judgment; namely, increased visual information may have more important consequences in some locations than in others, but it has importance in all situations. It may have more importance in street lighting than in office lighting, for example, as visual miscues in street lighting owing to missing, inadequate or distorted visual cues may result fatally for the victim, whereas in office lighting it may be the source of mistakes, of re-done work, and of unnecessary fatigue owing to the absence of the richness of cues which are required by the body for economic muscular operation.

With reference to the nine-days' old kitten, the researchers (Gibson and Walk) reported: "To make sure no hidden bias was concealed in the design of the visual cliff we conducted a number of control experiments. In one of them we eliminated reflections from the glass by lighting the patterned surfaces from below the glass (to accomplish this we dropped the pattern below the glass on both sides, but more on one side than the other). The animals still consistently chose the shallow side." They also tested the role of the patterned surface by replacing it on either side of the centerboard with a homogeneous grey surface. This removed both the "motion parallax" and pattern density clues, and as a result the animals moved without preference to either side. This showed that when the tactile cues dominated, the animals "trusted to the strength of the plate glass."

These reactions were not the result of "knowledge" (Dr. Harrison's word), but of inherited reflexes. These reflexes are equally inherited by humans, and visual environments trigger them, either to our benefit or hazard. Benefits may range from the work in hand which is associated with the acquirement of food, shelter and the amenities of life, to the minor relief gained by looking at a patch of color that affords a change in the visual pace. Hazards may range from those that threaten life to those which merely disturb one's composure, and both benefits and hazards may be seen or merely "sensed." When they are seen they occupy a primary center of attention on the line of sight. When they are "sensed" they are submerged below the impact of the conscious centers of interest. When they are seen they are picked up on the line of sight giving conscious evidence of their presence. When they are "felt" they are picked up involuntarily from data coming in from outside the centers of attraction.

While it is desirable to make the benefits and hazards in artificially-designed visual space coincide with the centers of visual attraction, only one of them at a time can be handled by the line of sight—and at that moment it may be the wrong one. Therefore, the visual centers of attraction must be set up so that when the attention is occupied by one of them the rest are providing efficient data, via the nervous system to internal body terminals, to ensure that correct and adequate reflexes occur. These are less likely on a grey day or with artificial analogs of a grey day.

We will not have visual environments which consistently promote our welfare until we know how to tailor them to suit both our acquired and our inherited reactions. This is a large problem, and if it cannot be solved in short order one should not infer that it cannot be solved at all. Our paper is a very tentative beginning.

Answering Dr. Guth's questions in order, autocorrelation indicates the contrast population of a visual scene in terms of departure from a no-contrast reference state—or departure from "sameness." The street lighting scenes show a great deal of "sameness"—large areas of darkness in the one picture, and large areas of "lightness" (the roadway) in the other picture, so that the actual contrast population in the two pictures was not greatly different. However, the difference was such as to be vitally important to an observer, and the reader is referred to our reply to Mr. Meaker for more detailed comments.

The printed matter, likewise, was surrounded by a relatively large area of no-contrast background, which served to reduce the numerical difference between the two samples. A greater numerical difference could have been shown by masking more of the redundant background, but that would have introduced a different comparison scale from that used for the other scenes. Maybe a different scale should be used for sight-centered tasks, but that is for future study.

We agree that the evaluation of lighting systems as viewed from outside the visual space is not necessarily pertinent to their effectiveness inside the space, but at this stage of the work we were interested in finding out what could be measured by this method, and in this example we had two contiguous situations that could be photographed simultaneously under exactly the same conditions.

Dr. Guth's assumption that a glaring lighting system would be given a favorable autocorrelation rating does not necessarily follow. We do not know, as of now, what a favorable autocorrelation would be, and we cannot extrapolate from present results. We do know that within certain limits the greater the departure from "sameness," the greater the visual cues available to the observer for efficient and safe operation of visual space, but we do not yet know what these limits are. As a working basis it may be assumed that such limits coincide with present findings on glare, and work needs to be done on many environments that meet present glare restrictions but differ in departures from sameness. The bank example in the paper was one such comparison, but many more need to be made.

As for the "normalizing" process resulting in under reporting of information, the process does not report infor-

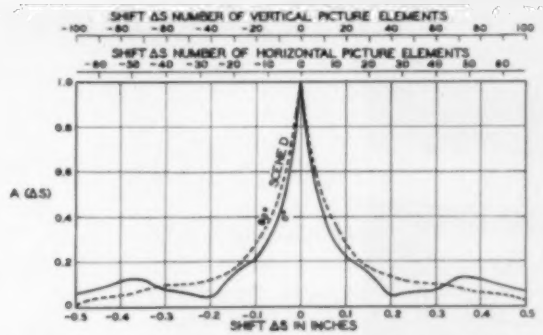
SHIFT ΔS NUMBER OF VERTICAL PICTURE ELEMENTS
SHIFT ΔS NUMBER OF HORIZONTAL PICTURE ELEMENTS
A (ΔS)
SCENE D
SHIFT ΔS IN INCHES

Figure A. (above and right). Autocorrelation plot for the scene shown at right. From Kretzmer, E. R.: "Statistics of Television Signals," Monograph 2008, Bell Telephone System Technical Publications, Fig. 5, page 7.

No. 9 "Crowd I."

mation but only the raw material, which a human observer can translate into information.

We are indebted to the Bell Telephone experts mentioned in the paper for the process which has been helpful in evaluating the relative effectiveness of visual scenes on television screens. As there is no essential difference between a television projection and a photographic projection, it can be equally well and reliably applied to the latter.

That there is a difference between the actual scene and a photographic representation, no matter how well taken, is quite true; on the other hand, however, photographs can be highly reliable representations of a visual scene. How important the residual difference between a good photograph and the actual scene may be we do not know; here we are being guided by common sense.

The color complication is resolvable, as mentioned above, but as we have to crawl before we walk, we started with black and white.

The size of the shift used in measuring a scene is a function of the population density of adjacent contrasts. The greater the population of information cues the smaller the shift needed to show a departure from autocorrelation. When a one-mil shift, or any other size of shift, is used, it is a shift simultaneously over the whole scene. That is, adjoining segments are shifted over the whole scene simultaneously. In some cases the shift may coincide with an assumed size of the foveal region of an observer, but there is no relation between them.

The second point is that the material for this investigation lies between these extremes; that is, between situations giving a "spike" or a flat line. A white stripe on a black background would not give a spike, as Mr. Meaker assumes, but after the first one-mil shift would degenerate into a horizontal line just a little below the top of the diagram, showing a great degree of autocorrelation and very little in the way of information cues.

Mr. Meaker's assumption that the slope of the curve may be more significant than the ordinate values may be correct. It is the slope rather than the ordinate values that has been used by the Bell Telephone Laboratories researchers to predict the number of "bits" required to transmit a picture in visual signals, but in their opinion this step has no application to what we are trying to measure.

Masking scenes so as to measure only areas having a large population of contrast cues, as in the street lighting scenes, could be done, but it would only tell part of the story. The degree to which redundancy exists, both as a background to support a pattern of visual information cues, and as a diluting mask for such cues, is also important.

We need a measure for the whole field of view, and not just for sight-centered tasks. The reason, as we tried to show in the introductory paragraphs of the paper, is that there are two modes of visual perception. There is "literal" perception, which is perception, mostly below the conscious threshold, of the substantial and spatial visual world, and "schematic" perception, which is the conscious perception of the world of useful and significant things to which we ordinarily attend. This latter shifts continually from one visual center of attraction to another.

"Literal" perception is dependent primarily on stimulation rather than on consciously recognized meaning or mental elaboration. Gradients of the pattern density or differential "motion parallax" types are the stimulus correlates that trigger orientation reflexes with reference to perceived space and perceived locomotion. A measurement of the degree of revelation, or of suppression, of these contrast gradients over the whole field of view, in terms of their departure from "sameness," can be an important clue to the degree to which the visual space serves the welfare (health and safety) of the occupants.

Regarding Mr. Meaker's question, "Does it follow that maximum information results from a 50 per cent area graph?", Fig. A of this discussion shows the plot of autocorrelation for the scene in Fig. 2. Inspection shows that the area of this graph is much below 50 per cent, yet the scene measured is chock-full of information cues.

We do not know just what departure from "sameness" (50 per cent, 90 per cent, 95 per cent) would indicate either a maximum or an optimum yield of information cues. We only know that 100 per cent "sameness" indicates no information cues in the sense used here, and zero "sameness" also indicates no information cues. This is because zero "sameness" occurs when a confusion pattern fills the field of view, with no contrast predictable from any other contrast. We do not know where the most desirable yield in information cues occurs between these conditions of 100 per cent and zero per cent "sameness," but it would seem to be closer to the zero than the 100 per cent condition.

INSTALLATION AT PHILADELPHIA ELECTRIC CO. DISTRICT OFFICE PENN AND SWEDE STS. NORRISTOWN, PA.

Lighting a Showroom

LIGHTING OBJECTIVE: To provide general illumination and an attractive environment for the merchandising of electric appliances.

GENERAL INFORMATION: This showroom-merchandising area occupies a space 44 feet wide by approximately 72 feet long with a ceiling height of 11 feet. Adjoining area (44 feet wide by approximately 16 feet deep), shown in background of photo, is used as a collection area. Colors and reflectances of the major room surfaces are: ceiling, egg-shell white (70% RF); walls, egg-shell white (60% RF); floor, rose grey (30% RF).

INSTALLATION: General lighting in this merchandising area is provided by 56 Metalcraft Products Co., Inc. catalog No. PL 486-40 recessed four- by four-foot fluorescent luminaires each equipped with an acrylic plastic diffuser and six 40-watt T-12 warm white rapid-start lamps. These units are arranged as follows: the center row is in groups of four with a 12-inch space between ends; the units on each side of this are grouped in twos on nine-foot centers with four feet between their ends and the sides of the center row; the single units, shown at right in photo, are also on nine-foot centers but are 18 feet from right side of center row.

Supplementary lighting is provided by 25 Day-Brite Lighting Inc. catalog No. 80175 recessed adjustable units equipped with 150-watt PAR-38 side prong incandescent lamps. Eighteen of these units are located as shown above on nine-foot centers five feet from the sides of the center row. The remaining seven are located at right in photo on four-foot centers.

Average general level of illumination is 170 footeandles. Brightnesses at that time are: luminaires (fluorescent) at 45 degrees, 1085 fL; ceiling, 35 fL; walls, 60 fL; floor, 50 fL.

Lighting designed by James R. Rodisch, Philadelphia Electric Co., Philadelphia, Pa.

Lighting data submitted by James R. Rodisch and George T. Anderson, Jr., Philadelphia Electric Co., Philadelphia, Pa. as an illustration of good lighting practice and to aid in the design of similar installations.

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Electroluminescent Lamp Brightness Measurement

By ROBERT W. WOLLENTIN
STANLEY R. GOLDFARB
D. CLIFFORD BELL

Some of the problems encountered in the measurement of brightness of electroluminescent light sources are discussed in this paper. The influence of operating voltage, frequency, and temperature on lamp brightness is considered, with emphasis placed upon the calibration and adaptation of the Spectra Brightness Spot Meter for use in the measurement of brightness of colored light sources.

THE RECENT acceptance by commercial and military organizations of electroluminescence as a source of illumination has emphasized the importance of accurate brightness measurements of these sources. For many development and research activities on light sources, it is adequate simply to obtain relative brightness data through the use of a reliable instrument capable of yielding an acceptable degree of reproducibility. For marketing and other purposes, however, it is imperative to establish the absolute brightness of the electroluminescent light sources, which may emit light of almost any hue or saturation. Brightness measurement is particularly troublesome when considering electroluminescent sources since levels are sometimes very low and the color of the emission may alter somewhat with time of operation or, more drastically, with a change in excitation frequency.

Since the authors have found the Spectra Brightness Spot Meter (Model UB 1/2, with an external meter) to function with an acceptable degree of reproducibility, and since this instrument is in wide use as a measuring tool for electroluminescent light sources, this paper is concerned with problems involved in adapting it to the accurate determination of electroluminescent source brightness.

There are three general sources of measurement error. One is inherent instrument inaccuracy; another is source fluctuation (both of calibration source and unknown source); the third is "pilot error," not discussed here. Particular errors found in brightness measurement are discussed below.

Instrument Error

Focusing Barrel Adjustments

The light impinging on the brightness meter detector is governed primarily by a fixed aperture within the optical system except when a Micro Spectar Lens is employed. If the instrument focusing barrel is adjusted after calibration using a Micro Spectar Lens, the change in sensitivity may be in the order of 20 to 30 per cent, depending upon the extent of the adjustment. If it is adjusted after calibration using a single element or the Spectar Lens the error is in the order of two per cent. To eliminate these errors entirely, the best procedure is to set the focusing barrel at infinity during calibration, regardless of which lens is employed, and not to alter it thereafter.

Color Response

Wide variations were observed when two or more Spectra Brightness Meters were employed to measure the brightnesses of electroluminescent lamps emitting in various spectral energy regions. For example, the measured brightness values on red-emitting lamps differed as much as 300 per cent for the various meters employed. In another case, two specific Ultra-Sensitive Spectra Meters, which were adjusted to read the same when viewing a standardized 9.0-footlambert white source, were found to differ by 15 per cent and 29 per cent in their readings on green and blue-emitting electroluminescent lamps, respectively, but agreed in the readings for a yellow-emitting lamp.

Lens Selection

A supplementary lens should be employed where it is desirable to monitor the brightnesses of small areas. However, since the uniformity of electroluminescent lamp brightness varies over its emitting surface, it is desirable to monitor an average brightness. Obviously, if the viewing area were too small, only a few phosphor particles would be measured. Therefore, to achieve an average brightness reading, one should monitor a large area on the lamp. Since the opal glass used with the standard source is nonuniform, the Spectra Meter is calibrated out of focus, thereby monitoring the

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHORS: Messrs. Wollentin and Goldfarb: Westinghouse Electric Corp., Bloomfield, N. J.; Mr. Bell: Chicago Miniature Lamp Works, Chicago, Ill.

average brightness of a large area. Similarly, it is recommended that the instrument be used as it is calibrated for monitoring nonuniform sources. For example, when the Spectar Lens is held against a flat source, it will monitor the average brightness of a ⅞-inch diameter area. If an Ultra-Sensitive ½-degree Meter with a Spectar lens is focused on the source, it will monitor the brightness of a $^1/_{20}$-inch diameter area.

Calibration to White Standard Source

Detailed recommendations for an accurate calibration procedure can be found in Appendix A of a report on Air Force Contract 33(616)-5811.[1]

Source Fluctuation

Temperature Effect on Electroluminescence

It has been shown by numerous investigators[2-12] that temperature has an influence on electroluminescence brightness. The degree of this influence on brightness is dependent upon the composition of the phosphor. For example, the effect of temperature on the brightness of a green-emitting phosphor embedded in a plastic medium is illustrated in Fig. 1. Here it may be seen that the change in brightness is +12 per cent for a 10°F increase in temperature from 75°F to 85°F. In this temperature *vs.* brightness experiment the lamp was energized only long enough to monitor its brightness. It is apparent that ambient temperature should be controlled and reported when quoting electroluminescent lamp brightness values.

Operating Temperature Equilibrium

During high-voltage and high-frequency operation, an electroluminescent lamp may produce heat dependent upon the electrical losses in the phosphor and embedding medium. If this leads to a heat rise in the lamp, brightness will also be influenced. Therefore, before measuring the brightness of an electroluminescent lamp, it should be operated long enough to reach temperature equilibrium. The time required to reach an equilibrium condition depends on the lamp operating and environmental conditions and should be determined experimentally before the readings are taken. It is important that the surface temperature of the lamp be recorded at the time of brightness measurement.

Voltage Dependence

Since the light output of the electroluminescent lamp has been shown to be exponentially dependent upon voltage,[2, 13-20] the accuracy of the voltmeter used to establish lamp voltage is very important. An instrument of at least 1 per cent accuracy is recommended to minimize this error.

Frequency Dependence of Electroluminescence

The brightness of electroluminescent lamps has generally been observed to vary linearly, or slightly less, with frequency.[2, 4, 8, 13-27] Consequently, careful control is necessary before stating the frequency at which the lamp is operated during measurement.

Aging of the Brightness Standard

A 400-watt, gas-filled projection lamp is recommended as a primary standard. Such a lamp, calibrated by the Bureau of Standards and used in conjunction with a 0.1 per cent voltmeter and an optical bench, has proven to be very reliable. Projection lamps of the type mentioned display a change in color temperature of about one hundredth of a degree per hour of burning at 2350°K. Periodic reversal of the voltage polarity tends to minimize the darkening of the envelope. The aging of the

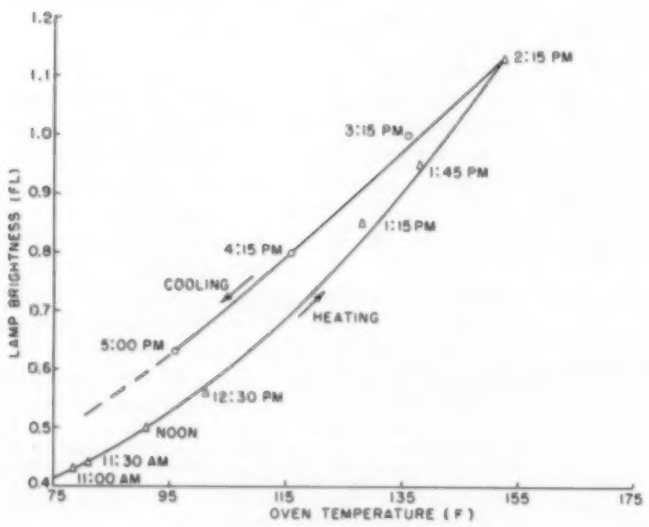

Figure 1. Dependence of electroluminescent lamp brightness on temperature at 120-volt, 60-cycle operation.

standardized source may be reduced by using a secondary standard. The Photo Research Standard Brightness Source is suitable for this purpose.

At 2350°K, a 0.1 per cent change in lamp operating voltage on the standard lamp will cause a brightness error of 0.4 per cent. A piece of flashed opal glass to diffuse light will lower color temperature by about 60°K; this should be considered when the lamp is calibrated for color temperature.

Standard Source Construction

The Photo Research Standard Source is equipped with a housing to facilitate filter insertion. The housing casts a shadow around the edge of the opal glass which lowers the average brightness of the source as much as five per cent. This leads to an error in the calibration of the Spectra Brightness Spot Meter unless a supplementary lens is utilized which monitors only the unshadowed center portion of the opal glass.

Distortion of Brightness Standard Supply

If the wave form of the a-c supply to the Photo Research Standard Source is distorted, the brightness of the Standard Source will change depending upon the amount of distortion. Since the Standard Source is equipped with a transformer type regulator, the unit should utilize an ordinary 115-volt supply directly to minimize distortion.

Masking Errors

If, for any reason, the brightness of a lamp is to be monitored through a mask, the instrument should be focused on the mask before reading the lamp. If the mask is out of focus and the measurement is taken close to its edges, light attenuation will occur. This is to be distinguished from the "edge effect" observed on electroluminescent lamps, where the edges of the lamp are dimmer than the middle.

Instrument Calibration for Brightness Measurement of Colored Light Sources

An investigation was performed to determine the extent of instrument error due to color of the light source. A study of four Model UB 1/2 Spectra Brightness Spot Meters was made in the following manner. Six Corning Glass filters and a National Bureau of Standards standard filter were selected to cover the spectral range of red through blue. The luminous transmissions of the Corning filters were determined with the aid of a Perkin-Elmer Model 13 U Spectrometer and an IBM 610 Computer. Transmission data received from the National Bureau of Standards were compared with the measured transmission for the standard filter in order to determine the accuracy of the present measurement. This accuracy proved to be within 0.6 per cent. Known brightnesses of various colors were set up on an optical bench using a National Bureau of Standards calibrated incandescent 2350°K source and opal glass diffusing plate in combination with the filters whose luminous transmissions had been determined.

Each brightness meter was calibrated to the white 2350°K standard lamp and opal glass source and was used to read the brightnesses of the various filter-standard sources. The ratio of the true brightness to the measured brightness is the meters' correction factor for the source color. Brightnesses were selected for the standard source plus filter combinations to yield meter readings which were at least 40 per cent of full scale in order to hold error due to scale error to a minimum. The data obtained in this study are shown in Table I. The magnitude of the error may be seen by comparison of the correction factors. The best instrument (521) shows a maximum error of seven per cent, while the poorest (084) deviates by 37.6 per cent in red, 31 per cent in blue, and three per cent in yellow.

One method which may be used to derive accurate brightness values is to determine the true spectral response of the instrument and the spectral energy distribution of the light to be measured. An integration procedure will then yield the true brightness. However, as a method for general use, this is not considered to be practical.

A simple visual judgment of the source color and the application of a correction factor derived

TABLE I—Color Correction Factors for Spectra Brightness Spot Meters.

Filter Number	3215	2424	3384	4010	4084	4407	5031
Color	Red	Light Red	Yellow	Green	Deep Green	Pale Blue	Deep Blue
Transmission	0.208	0.280	0.855	0.078	0.171	0.249	0.131
Meter 083 Correction factor	0.977	0.936	0.961	1.06	1.06	1.06	1.16
Meter 084 Correction factor	0.609	0.675	0.961	1.43	1.29	1.24	1.27
Meter 085 Correction factor	1.20	1.09	0.970	1.00	0.940	0.940	0.970
Meter 521 Correction factor	1.00	1.04	0.990	1.02	1.04	1.04	1.07

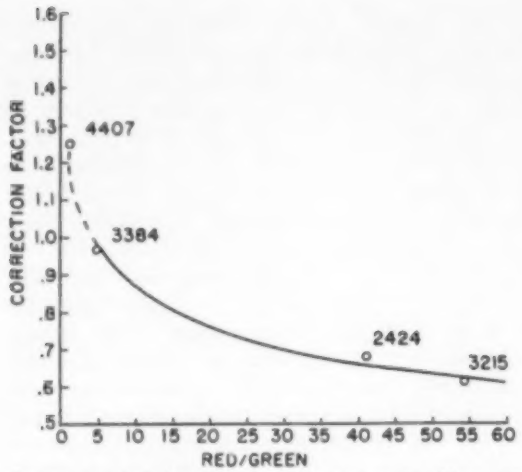

Figure 2. Variation of correction factor for Meter 084 with red/green ratio.

through calibration of the instrument to a "standard" source of similar color, was also considered. This system seems practical for meter 521 where the detector sensitivity does not deviate very radically from true eye sensitivity. For the other instruments tested, 084 in particular, this method which relies on visual judgment of color would be inaccurate. A more reliable method based upon filter photometry to indicate color is as follows:

(1) Calibration curves for the particular instrument are derived on the basis of three parameters. These parameters are ratios of the relative quantity of light passing through arbitrary red, green, blue, and yellow filters. The ratios red/green, blue/yellow, and blue/footlambert (as measured on the brightness meter) are plotted *vs.* the known correction factor of standard filters. Smooth calibration curves (Figs. 2, 3, and 4) are drawn in view of a reasonable assumption that meter sensitivity varies continuously over a narrow spectral range. The data from which these curves are derived are shown in Table II.

(2) The light output of the unknown source is measured through the four filters, mentioned above, and the above ratios are calculated. A correction factor is then read from the calibration curves and is applied to the footlambert reading to yield corrected brightness. Usually, red through yellow light sources will fall within the area of the curve based on the red/green ratio, yellow-green to blue-green emitting sources fall in the area of the blue/yellow curve, while green to blue emitting sources fall within the area of the blue/footlambert curve.

As a check on the validity of this method, four additional filters (whose luminous transmissions differed from those of the filters used to plot the calibration curve) were measured for luminous transmittance and then, in combination with a white standard incandescent lamp, were treated as unknown sources. The parameters described above were determined and correction factors were obtained from the calibration curves. These correction factors are compared in Table III to the calculated true correction factors for those particular filters. The data agree very well except in one case, where a difference of 6.5 per cent from the true correction factor was noted in the deep red region.

A fourth calibration curve (Fig. 5) was generated by plotting the ratio of the logarithm of the red/green ratio *vs.* correction factor. This resulted in a straight line relationship, for the particular meter employed, except for a single deviation in the deep blue area. This curve was not anticipated to be a straight line relationship and may only be coincidental.

In an experimental application of the three parameter calibration described above, a measurement was made on a green-emitting electroluminescent source using Spectra Brightness Spot Meter UB 1/2 084. The apparent brightness observed was 0.80 footlambert. The values of red/green, blue/yellow, and blue/footlambert were 1.1, 1.0 and 0.30, respectively. Correction factors of 1.25, 1.26 and 1.24 are read from Figs. 3, 4, and 5,

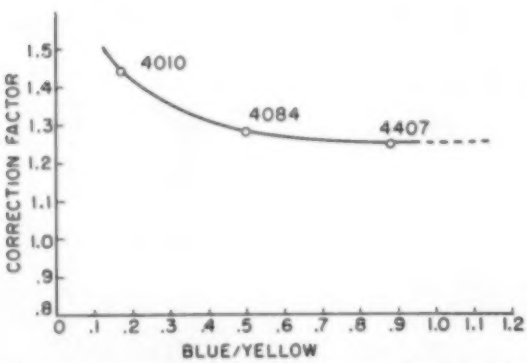

Figure 3. Variation of correction factor for Meter 084 with blue/yellow ratio.

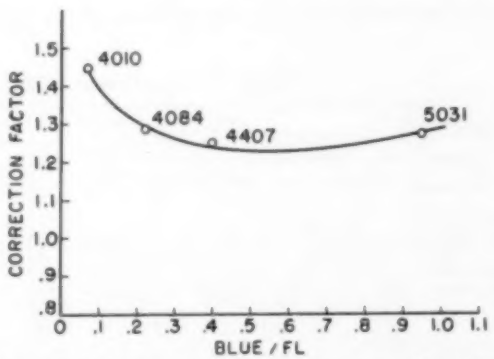

Figure 4. Variation of correction factor for Meter 084 with blue/footlambert ratio.

TABLE II—Color Ratios and Correction Factors for Various Source Colors.

Meter 084 Filter Number	3215	2424	3384	4010	4084	4407	5031
Blue/yellow	0.00380	0.00330	0.0167	0.168	0.494	0.875	2.60
Red/green	54.3	40.9	4.77	0.303	0.765	0.903	0.296
Blue/fL	0.00290	0.00250	0.0104	0.0720	0.224	0.398	0.954
Correction factor	0.609	0.675	0.961	1.43	1.29	1.24	1.27

respectively; the curve changes too rapidly at the coordinate of red/green = 1.1 to allow use of Fig. 2. Application of the average correction factor, 1.25, to the apparent 0.8 footlambert brightness reading yields a corrected brightness of 1.0 footlambert. A brightness measurement of this same electroluminescent lamp was made using Spectra Brightness Meter 521, whose correction factor in the green region is approximately 1.04 (from Table I). In this instrument the correction factor is fairly constant throughout the spectrum. The apparent brightness observed was 0.95. Application of the 1.04 correction factor yields a corrected brightness of 0.99 footlambert. This compares favorably with the 1.0 footlambert value obtained using Meter 084, which attests to the accuracy of the calibration curves derived for that instrument.

Summary

Because of the many problems associated with the measurement of electroluminescent lamp brightness, special considerations must be given to the choice of measurement apparatus and the procedures that are to be employed in the operation of both the measurement apparatus and the electroluminescent lamps. Since the electroluminescent lamp is capable of emitting brightness levels of various hue and saturation, ranging from less than a few hundredths to several thousand footlamberts, it is imperative to employ a brightness meter capable of a high degree of dependability. Because of extensive application of electroluminescent lighting, it is also desired that the brightness apparatus be portable. The Spectra Brightness Spot Meter generally satisfies these requirements, except for inherent deviations from true eye sensitivity in the detector. The degree of deviation from eye sensitivity was found to vary among the various instruments. Consequently, if the meter is to be employed successfully, the degree of variation from true eye sensitivity must be determined to allow derivation of appropriate correction factors.

The calibration procedure recommended herein considers first the standard approach for calibration of the instrument to a standardized white source, followed by an appraisal of the deviation from eye sensitivity by use of filter photometry. This procedure, when applied to several Spectra Brightness Spot Meters, disclosed that, generally, the internal filter-photocell combinations closely matched eye sensitivity over most of the spectrum. However, in one of the meters, rather wide deviation from eye sensitivity was found, emphasizing the importance of calibration for various colors.

In those meters where the deviation from eye sensitivity is small, it is generally sufficient to apply correction factors independent of a color identification of the source other than by visual

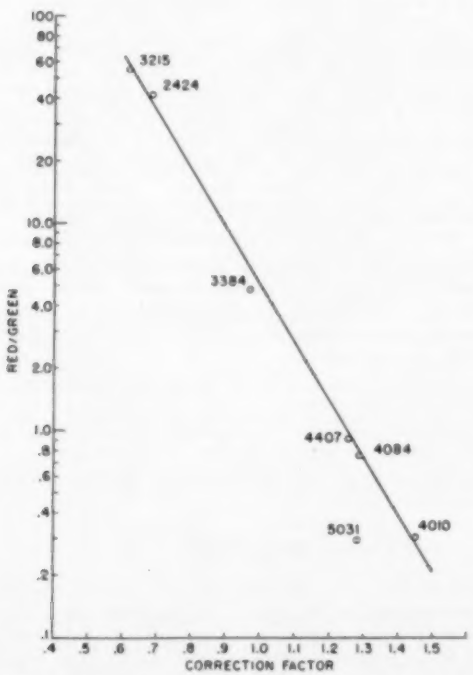

Figure 5. Variation of correction factor for Meter 084 with the logarithm of the red/green ratios.

TABLE III—Evaluation of the Accuracy of the Calibration Curves.

Meter 084 Filter Number	2434	3304	9782	4303
Color	Red	Yellow	Pale Blue	Deep Blue
Blue/yellow	0.00267	0.00377	1.03	2.01
Red/green	25.4	11.8	0.502	0.340
Blue/fL	0.00173	0.00257	0.430	0.737
Theoretical correction factor	0.770	0.838	1.25	1.287
Correction factor from:				
Fig. 2	0.72	0.85		
Fig. 3			1.25	
Fig. 4				1.24
Fig. 5	0.75	0.87	1.23	
Per cent error	6.5-2.6	1.4-3.8	0-1.6	3.7

appraisal. However, where a larger variation from eye sensitivity over the spectrum exists in the meter, it is advisable to ascertain a more precise source color identification than is possible by the human eye. While it is possible to determine color by several methods, the one recommended is based upon filter photometry where the Spectra Brightness Spot Meter is supplemented with selected filters which broadly cover the visible spectrum. The ratios of the instrument responses through the various filters provide identification of the color of the light source which then permits selection of the proper correction factor to be employed. It is imperative in this method that the same filters which are used to determine the color ratios in the calibration of a specific Spectra Brightness Spot Meter are always used for color analysis with that same instrument.

Besides the problem of color encountered in the measurement of electroluminescent lamp brightness, several other considerations peculiar to these light sources are of importance. The major problems are the variation in the brightness of the emitting surface area of the lamp and the sensitivity of lamp brightness to exciting voltages, frequencies, and temperature during operation. Proper control of these variables during lamp operation is mandatory. In the interest of reporting meaningful brightness values, it is necessary to state the conditions of temperature, voltage and frequency at the time of measurement.

The recommended general method for brightness measurement of electroluminescent lamps may also be employed in the measurement of brightness of other light sources or emitting surfaces whose emission is a continuous spectrum. However, it is not suitable for use in the measurement of brightness of sources whose emissions are composed of line emission, line emission superimposed upon continuous spectra or composites of relatively narrow bands located over various spectral regions. Consequently, the method is not applicable to fluorescent and other mercury discharge lamps. No effort was made, at this time, to adapt the Spectra Brightness Spot Meter to the measurement of brightness of a source whose emission is a composite of independent relatively narrow bands. Such composites are often used to yield white emission in electroluminescent lamps. For example, blue and yellow emitting phosphors may be incorporated into a single lamp to result in white emission. Other blends of red- green- and blue-emitting phosphors may be similarly employed in various proportions to yield white emissions whose spectral energy distributions may differ widely. Since the departure from eye sensitivity varies in degree over the visible spectrum in the Spectra Brightness Spot Meter, the instrument is not recommended for use in the measurement of true brightness of such sources unless it is first calibrated to a standardized source of similar spectral emission.

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DISCUSSION

KEITH H. BUTLER:* Having been involved in the problem of measurement of the output of electroluminescent lamps with the color of aviation red, I can agree that the Spectra Spot Meter requires considerable care when color is involved. The National Bureau of Standards has developed a very

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precise method for determining whether or not a source matches aviation red in color and it would have been useful to include a reference to this method in the bibliography.[1]

The authors depend for calibration on combining filters of measured transmissions with an incandescent lamp of 2350°K temperature. While this is generally sufficient, there is still a possibility of error with measurements in the deep red. The 2350°K source has peak emission beyond 1000 millimicrons; hence, a rising spectral energy distribution in the red. The usual electroluminescent phosphors have a falling energy distribution in the red; thus, the calibration cannot be completely exact though the error may be rather small.

The authors are entirely correct in stressing that, "the surface temperature of the lamp should be recorded at the time of brightness measurement." If present commercial electroluminescent lamps are operated at frequencies in the kilocycle range in efforts to obtain high brightness, the heat dissipation problem becomes very severe and, lamp brightness will drop to a low level unless external cooling is used.

Fig. 1, showing a steady rise in lamp brightness from 0.4 to 1.1 footlamberts with increase in ambient temperature from 75°F to 155°F, is different from other published data on the effect of temperature on electroluminescence. Our data[2] show only 10 per cent increase in light output from 75 to 150 degrees, with a rapid decrease above 150°F. Can the authors explain the unusual behavior of their lamps?

1. Specification MIL-L-25467A (ASG), amendment-1, paragraph 4.4.4.1 (June 3, 1957).
2. Butler, K. H.: *Science 129*, p. 544 (1959).

RALPH STAIR:* The accurate measurement of electroluminescent lamp brightness, as other radiometric evaluations, requires precise instrumentation. The color-uncorrected Spectra Brightness Spot Meter cannot be accepted as a precise measuring instrument without proper correction by filters. The barrier layer cell covered with a suitable Viscor filter has been transformed into a satisfactory light meter for relatively high light levels. Similarly, but with somewhat greater difficulties, the Spectra Brightness Spot Meter should lend itself to approximate color correction through the use of the proper filters for the particular photomultipliers employed. Not until this correction is made can one depend upon the resulting measurements of varied colored sources, such as the electroluminescent lamp, that also change in color with changing operating conditions.

DOMINA E. SPENCER:** Photoelectric meters such as the Spectra Brightness Spot Meter are so easy to use that there is a temptation to assume that their readings are correct without further analysis. It is heartening to find that the authors have carefully analyzed several sources of error. Their procedure for color calibrating the meter appears to be sound and sufficiently accurate for the purpose at hand.

I am particularly interested to note that the authors have found errors as great as 30 per cent associated with focusing of the lenses.[1] There is a very serious question as to whether any photoelectric instrument employing a lens system is actually measuring helios (brightness). For some purposes, the difficulty can be circumvented by leaving the lens in a fixed position as these authors have done; for others it can be handled by calibrating the instrument as a function of distance. For more complex problems, however, where light from sources at several distances must be measured simultaneously, photoelectric instruments employing lenses cannot be made to give correct measurements. Such problems as measurement of reflected glare, measurements in fog, measurements of pavement helios (brightness), and goniophotometric measurements all encounter this impasse. Sensitivity has been gained by introducing lenses, but at a great price: the instrument no longer measures the proper photometric concept. Apparently there is a need for an improved version of the photoelectric photometers—a lensless version which is designed so that it inherently measures helios (brightness) and has no focusing error.

1. Spencer, D. E.: "Lenses in Photoelectric Photometry," *Journal of the Optical Society of America*, Vol. 50, No. 11 (November 1960).

R. W. WOLLENTIN:* In response to Dr. Butler, we agree that a reference to the specification MIL-L-25467A (ASG) is useful. This specification was used in our effort on the WADD contract mentioned in the paper. A description of its application to that work is presented in the final report AF WADD-TR-60-189 on the subject contract.

It is recognized that a small error may be introduced in the measurement of deep red as a result of the use of a 2350°K source in the calibration of the brightness meter. However, it was felt that the error was probably sufficiently small so as to be of little concern. This is especially true in regard to measurements on the red-emitting phosphors recently developed and used in our laboratories. These phosphors display a rising distribution in the deep red and peak in the infrared.

The dependence of electroluminescent lamp brightness on temperature is a complex function of the materials present in the lamp, particularly of the phosphor itself and the lamp structure. Consequently it is not surprising that others observe a dependence upon temperature different from that observed in the paper. It is acknowledged that the temperature dependence shown in Fig. 1 is one of the most severe dependences observed; it was chosen for the purpose of maximum emphasis. Generally, a lesser dependence of lamp brightness on temperature is observed.

In answer to Dr. Stair, accurate measurement of electroluminescent lamp brightness certainly requires precise instrumentation for which there is no acceptable substitute. Our purpose in discussing the Spectra Brightness Spot Meter was not to advocate the use of this instrument as a substitute for precise instrumentation, but rather to call attention to the limitations of the Spectra Meter and propose a means whereby it may be used with increased accuracy and precision in electroluminescence activities.

The instrument would indeed be a much more useful tool if proper internal filter correction were provided by the manufacturer who, it is recognized, makes a reasonable effort to achieve this within limits dictated by economics. However, since precise correction is not achieved by the manufacturer, and many users are not in a position to provide correct internal filtering, the method of calibration suggested is a workable compromise which, in our opinion, will help to minimize misinterpretation and misuse of the instrument. Since the method suggested employs identification of source color through simple filter photometry, and correction factors are provided related to color, the proposed method provides consideration for changes in color with changing operating conditions of the source.

It is hoped that our efforts have pointed up some of the major problems in adapting the Spectra Brightness Spot Meter to measurements on electroluminescent and other colored light sources which will be of benefit to others. We regret the inability to suggest a solution to the problem of simultaneous measurement of light from various sources at several distances. This is a problem which has not occurred here and upon which no experience has been gained.

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Views and Opinions

Who's to Blame for Poor School Lighting?

Until I became a school board member, I was merely a veteran illuminating engineer. I was critical of school lighting and inclined to believe that the typical board is ignorant about light for learning, not interested in learning about light, and totally dollar conscious rather than quality minded. Now that I'm on a school board, I'm beginning to understand why good illumination is so hard to attain in the run-of-mine school.

As a board member, I'll still go along with "ignorant" though I no longer pin most of the blame for that ignorance upon the school boards of this country and Canada. Many members would like to know more, but as illuminating engineers, too often we have confused rather than taught the facts of light for schools. More on that shortly.

In part, the blame for low levels and quality of illumination in our schools lies in the low-bid regulations. To buy at the lowest price can affect the quality of the purchase from the original general contract right down through the sub-contractors and into the buying of school equipment. But—give the low bidder the job or the school board may have a messy taxpayers' suit in its lap, so price prevails. It will continue to prevail until we can arrive at national agreement, as illuminating engineers, on standards and then educate our school boards and even the taxpayers as to the importance of the standards to be maintained.

How can we expect boards and the taxpayers behind them to stop saying "It isn't worth the extra cost," when we have no accepted standards or real promotion by those who are in the position to specify or purchase good lighting equipment? The lighting industry itself has no common language nor brightness control specs. I believe that, as engineers, we pay too much attention to technical details rather than the broad benefits to pupils and teachers that could be had from concerted action.

Let's not be so scientific that we neglect to see the trees in the forest. A recommended practice on the shelf isn't worth anything if the children must face excess glare. Let's at least stop the glare even if we get a little commercial. We need the purely scientific facts to provide sound recommended practices, but we also need the commercially minded to put those practices to work.

The IES "Recommended Practice for Office Lighting" is complete and working. When the schoolroom practice is completed (soon I hope) let's tell the facts to every spec writer, engineer, architect, school superintendent and board member, to everyone who has any part in the purchase of school lighting equipment. Let's not forget to tell the lamp manufacturers, the makers of lighting equipment, producers of parts, the electrical contractors, just *one* story, the IES one.

To do that, we have to do a good job of showing how the recommended practice for schools improves the environment and reduces work errors and fatigue, while increasing productivity; in a word, how it raises *educational* standards for the benefit of pupils and teachers. If we don't weld all the pieces in the school lighting pattern into a unit, we will continue as we have been—in diffusion rather than direction. Benefits of concerted action are greater than those possible from slight technical gains.

An IES member with whom I have discussed these matters recently remarked that the Society sometimes has taken a holier-than-thou attitude toward sales promotion. He said, "You can pick any twenty-five architects at random, and you're lucky to find two per cent of them who are familiar with IES recommended practices." He believes that the same comparison would apply equally to manufacturers of office equipment, school boards, those in direct charge of purchasing for schools, and certainly electrical contractors. This, he believes, proves a weakness in the Society. We recommend, but we fail to educate. We talk to each other in IES. We don't talk enough to those who can benefit from our lighting recommendations.

A superintendent of construction for one of the largest school systems in the U. S. and Canada tells me that group action is the only way to get improved lighting across both countries. He adds the salty remark that one of the first moves would be to get company policies back of IES practices in order to circumvent delaying tactics of pinheads!

I believe that actualities in improved school lighting can come from promotion of standards to insure proper levels and brightness control as fundamentals. I'm an engineer, rather than a promotion man, so I'm not recommending how this should be done. But certainly the foundation should be agreement upon standards, to carry some sort of concerted educational program that will reach right down to the taxpayer.

If all goes well, we should have our school lighting standard soon. If all of us connected with illumination step together in educating the educators and everyone else related to school lighting, we will no longer see specs that read "shielded fixtures," but specs that will read "shielded to IES recommendations." Thousands of classrooms and millions of little Marys and Johnnies are waiting. We can help them. Will we?—GEORGE P. WAKEFIELD, *The Wakefield Co., Vermilion, Ohio.*

INSTALLATION AT ARROW CAMERA SHOP, 80 N. CHARLOTTE ST., POTTSTOWN, PA.

Lighting a Camera Store

LIGHTING OBJECTIVE: To provide general and supplementary lighting for the merchandising of cameras and other photographic equipment.

GENERAL INFORMATION: The sales area of this corner store is shown in plan in Fig. 2. Colors and reflectances of the major store surfaces are: ceiling, white (75 per cent reflectance); walls, perforated gold wall board (23 per cent reflectance); floor, light pastel green (30 per cent reflectance); columns and low wall, grey stone (18 per cent reflectance).

INSTALLATION: General illumination is provided by eight Electro catalog No. GT2M-440-RS troffers, each equipped with four 40-watt T-12 warm white rapid-start fluorescent lamps, and four Electro catalog No. GT2M-420-TS troffers, each equipped with four 20-watt T-12 warm white lamps arranged as shown in Fig. 2. These troffers are enclosed by flat Alba-lite glass panels.

Supplementary lighting over the counters is provided by eight Litecraft catalog No. F355 recessed downlights with three-inch apertures, each equipped with 75-watt R-30 spot lamps. Six Litecraft catalog No. G512 recessed adjustable downlights, each equipped with 150-watt R-40 flood lamps, are installed at the windows to highlight the planters shown at the right in the photograph above. Single-lamp fluorescent channels, equipped with 40-watt T-12 warm white lamps, are installed in the valances over the wall display cases while the floor display cases are illuminated with single-lamp fluorescent units.

A.I.A. File No. 31 f

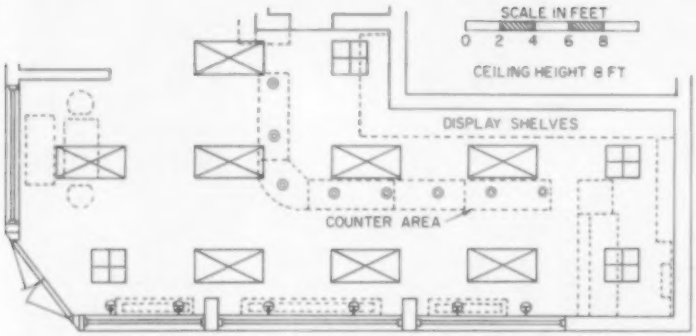

Figure 2. Plan view showing location of luminaires.

The combination of the general and supplementary lighting provides 100 footcandles in the general sales area and 110 footcandles on the counter top. Brightnesses are: fluorescent luminaires at 45 degrees, 950 fL; ceiling, 22 fL, walls (upper), 8 fL; column, 13 fL; and floor, 30 fL.

Lighting designed by Charles W. McQuiston, Philadelphia Electric Co., Philadelphia, Pa. Electrical contractor was Leonard H. Fritz, Pottstown, Pa.

Lighting data submitted by Charles W. McQuiston and George T. Anderson, Jr., Philadelphia Electric Co., Philadelphia, Pa. as an illustration of good lighting practice and to aid in the design of similar installations.

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THE GATEWAY TO THE WEST

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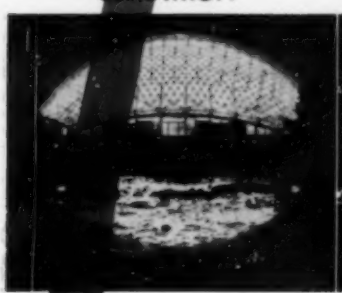


INVITES YOU TO
THE 1961
NATIONAL TECHNICAL
CONFERENCE

I·E·S

ST. LOUIS

SEPTEMBER 24-29
HOTEL CHASE—PARK PLAZA

WHAT'S GOING ON . . .
at the 1961 IES National Technical Conference? . . .

Sept. 24 Sunday	AFTERNOON Registration	6:00 PM	HOTEL CHASE—STARLIGHT ROOF St. Louis Section Hospitality Session "Ole" Heidelberg Nite	
Sept. 25 Monday Morning	9:30 AM	Official Welcome National Officers Reports IES Medal Award	1961 Fellows Announcements Adjournment	CHASE CLUB
Monday Afternoon	12 NOON REGENCY ROOM Second Annual Sustaining Membership Luncheon for official representatives and other executives.		2:00 PM IERI Report Session	CHASE CLUB
Monday Evening	Special Entertainment Events at Gaslight Square Tickets will be available.			
Sept. 26 Tuesday Morning Sessions	LIGHT SOURCES I REGENCY ROOM Design and Application of Panel-Type Fluorescent Lamps Operating Characteristics, Environmental Testing and Circuit Applications of Plastic Electroluminescent Lamps Fluorescent Lamps of Helicoidal Configuration Dissipation of Thermal Energy from Compact High Wattage Filaments in Close Proximity to Small Specular Reflectors		APPLICATIONS I CHASE CLUB Stroboscopic Effect of Mercury Lamps with Various Ballasts and Circuits Design of Large-Scale Electroluminescent Panel Lighting Systems Lighting Maintenance	
	PHOTOMETRY AND LIGHT CONTROL LIDO ROOM Zero Length Searchlight Photometry System Rotating Photocell Photometry for Fluorescent Luminaires Searchlight Beam Spreads from Horizontally Elongated Sources			
Tuesday Afternoon Sessions	LIGHT SOURCES II REGENCY ROOM Modified Starting-Voltage and Current Wave Shape Limits for Mercury Lamps Improvements in Deluxe and Specialty Fluorescent Lamp Colors with New Phosphors Characteristics of Ribbon Filament Lamps Xenon High-Pressure Lamps—New Designs Demonstrate Their Versatility New Developments in Compact Arc Lamps Design Parameters and Circuit Requirements of Appliance Type Fluorescent Lamps New Internal Reflector Projection Lamp Using "Cold Mirror" Construction Thermionic Emission Technique for Measurement of Cathodes		APPLICATIONS II CHASE CLUB Quartz Iodine Lamps and Football Field Lighting Combating Juvenile Delinquency with Light Lighting Apple Packing Plants Phytoillumination RESEARCH I LIDO ROOM Street Lighting and Accidents Further Appraisals of Luminaire Brightness	
Tuesday Evening	PROGRESS REPORT—KHORASSAN ROOM			

. . . A Full Technical Program You Can't Miss!

Sept. 27 Wednesday Morning Sessions

AVIATION LIGHTING — REGENCY ROOM

Hangar Lighting at New York International Airport

Development of a Lighting System for Air-Sea Rescue Operations

Heliport Lighting

Aircraft Exterior Lights for Preventing Mid-Air Collisions

APPLIED LIGHTING COMPETITION

CHASE CLUB

Wednesday Afternoon Sessions

BALLASTS — LIDO ROOM

Ballast Thermal Protection

Thermal Protection—A Necessary Evil

RESIDENCE LIGHTING FORUM — REGENCY ROOM

How to Increase Reading Speed

Picture Your Lighting Installations

The Whys and Hows of Recessed Lighting

CALCULATIONS — CHASE CLUB

Mathematical Equivalent to the "Scissors Curve"

Matched Filament and Reflector Contours

Lighting Perimeter Work Areas

Wednesday Evening

6:00 PM—President's Reception 7:00 PM—Banquet, Dancing

Brooks Chassaing, Toastmaster

KHORASSAN ROOM

Sept. 28 Thursday Morning Sessions

APPLICATIONS III — CHASE CLUB

Operational Analysis of Integrated Air Troffers

Convective Transfer of Lighting Heat Loads

Lighting for Future Environments

STREET LIGHTING I — REGENCY ROOM

Effectiveness Ratings for Roadway Lighting

Light Distributions for Effective Control of Glare in Roadway Lighting

Roadway Brightness Studies

RESEARCH II — LIDO ROOM

New Light on Visual Threshold Contrast

Visual Perceptibility of Variations in Illumination

Thursday Afternoon Sessions

APPLICATIONS IV — CHASE CLUB

Design Considerations in a Small Multi-Use Auditorium

Comparisons of Recessed, Ceiling Mounted and Suspended Office Lighting Systems

Commercial Applications of Higher-Loaded Fluorescent Lamps

STREET LIGHTING II — REGENCY ROOM

New Approach to Four-Way Luminaire Design

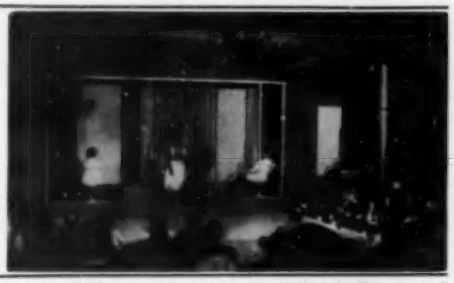
An Outdoor Fluorescent Luminaire with Optimum Light Output Over a Wide Temperature Range

Sept. 29 Friday

Council and Committee Meetings

THIS SOCIAL CALENDAR . . .

will make you glad you came!

Sept. 24 Sunday	6:00 PM	St. Louis Section Hospitality—"Ole" Heidelberg Nite HOTEL CHASE—STARLIGHT ROOF
Sept. 25 Monday	9:00 AM—Ladies' Coffee PARK PLAZA—GEORGIAN ROOM 10:00 AM—Tour of Shaw's Botanical Gardens and Climatron	1:00 PM—Luncheon at Bevo Mill 2:30 PM—Small groups to art museum . . . or residential suburbs . . . or antiquing at Gaslight Square
Monday Evening **Plan on this for sure**	A GALA EVENING AT GASLIGHT SQUARE Gaslight Square . . . an era reborn. Listen or dance to real Dixieland bands at the Opera House, Montileone's, Marty's, Smokey Joe's, The Other Side and many more. Theatre-bar at the Crystal Palace. A limited number of tickets will be available at the Conference for these two performances. Be sure to indicate your desires promptly.	
Sept. 26 Tuesday	9:00 AM—Ladies' Coffee PARK PLAZA—GEORGIAN ROOM 10:00 AM—Tour of Grant's Farm	1:00 PM—Luncheon at St. Alban's Farm and return through Washington University and residential areas.
Sept. 27 Wednesday	9:00 AM—Ladies' Coffee PARK PLAZA—GEORGIAN ROOM 10:00 AM—Tours to St. Louis Cathedral, New Plaza Area, Riverfront Showboat and Campbell House	AFTERNOON Residence Lighting Forum REGENCY ROOM
Wednesday Evening	President's Reception, Banquet, Dancing	
Sept. 28 Thursday	9:00 AM—Ladies' Coffee PARK PLAZA—GEORGIAN ROOM 10:00 AM—Small group shopping trips to Clayton, downtown or Westroads. Luncheon and transportation will be arranged.	AFTERNOON Open

You can arrange to visit these and other outstanding lighting jobs in the greater St. Louis area. Transportation will be arranged.

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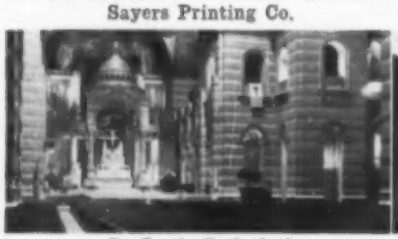
St. Louis Air Terminal

Pope Pius Library



St. Louis Cathedral

The Old Court House

Mc Donnell Aircraft

LIGHTING NEWS

British IES Publishes New Interior Lighting Code

The British Illuminating Engineering Society has recently introduced the fifth edition of its Code of recommendations for lighting in all industrial, commercial and residential interiors. The new Code represents an innovation for the Society in that it recommends, in addition to lighting levels for specific areas, a minimum amenity level of 15 lumens/square foot to emphasize the importance of lighting as a background to living as well as a working necessity.

The Code introduces a newly adopted concept concerning the relationship between daylight and electric light, stating that recommendations are applicable to both kinds of illumination, that electric light be used for both functional and architectural purposes and that separate treatment of natural and artificial light, as recommended in the previous edition of the Code, is unnecessary. This new approach is expected to allow architects and builders greater freedom in building design and better solutions to the problems of heat loss, window glare and insulation which resulted from the traditional concept of daylighting as a separate and self-contained source of interior illumination.

An increased emphasis on quality and comfort of lighting is provided in the new Code by comprehensive recommendations dealing with modelling, direction, color, texture, brightness relationships and glare control. Recommended values of glare index published side-by-side with recommended illumination levels and a set of tables for the determination of the Glare Index for any general lighting installation are expected to assure high quality interior lighting design.

Copies of the Code may be obtained from the British IES, 32 Victoria St., London SW1, England.

19 Symposiums Scheduled for Industrial Building Exposition

A series of 19 conference sessions, planned to cover all major problems involved in the construction and modernization of industrial facilities, will highlight the Second Industrial Building Exposition and Congress, scheduled to take place at the New York City Coliseum, September 25-28.

Problems to be considered during the first two days include: plant location, contract evaluation, lighting, heating-ventilating-cooling, financing, plant expansion, effect of building design on employee morale and productivity and systems for comparison of standard foot costs. The third day of conference sessions will be devoted to the study of effective construction procedures, including the problems of infrequent building, management of the company's plant engineering staff for construction, modernization procedures and construction methods and materials.

Complementing the symposium sessions will be eight major categories of exhibits —structural materials and components, mechanical, electrical, heating and air handling components and equipment, employee services, plant sites and services, financing and auxiliary services.

Complete program information and registration material for the Exposition is available from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

H. R. H. Prince Philip, Duke of Edinburgh, recently named the first Honorary Fellow of the British Illuminating Engineering Society, accepted his Certificate of Fellowship at a meeting which also marked the formal introduction of the new British IES Interior Lighting Code. Dr. W. S. Stiles, president of the Society, who presented the certificate, is seated at Prince Philip's right.

Home Lighting Training Course Prepared by IES Subcommittee

A complete package for a training course in home lighting, prepared by a subcommittee of the IES Residence Lighting Committee, is now available from the Technical Office at IES Headquarters. Designed to provide the instructor with all materials necessary for teaching home lighting techniques, the packet includes an instructor's outline, *IES Recommended Practice for Residence Lighting*, the recently published *Lighting Keyed to Today's Homes*, three Better Light Better Sight Bureau publications, *Lighting for Better Living Activities Book*, *Lighting for Better Living Summary Sheets* and *Lighting Fixtures Guide*, and a set of 100 slides available on a loan basis for two-week periods. The instructor's outline contains a detailed listing of material to be covered in the course, as well as suggested demonstrations, suitable reference material and a complete script for use with the slides.

The course is divided into four sections —basic lighting information, surface attached lighting units, table and floor lamps and built-in and decorative lighting. It was prepared under the co-chairmanship of Mary B. Taepke and Elizabeth Meehan.

The complete training program packet is being sold for $7.50, its cost to the

Here and There at IES Contests

Toronto Section's ALC contestants, l. to r., front row: W. R. Pringle, Lloyd Collins (second, Class II), Gwen Butterworth (first, Class I), D. J. Quigg, Ron Mathews (first, Class II). Back row: D. J. McKenzie, S. D. Hughes, Fred Sanger and A. W. Henschell.

Eight entrants in Milwaukee's Section's ALC were, l. to r.: Mert Baker, Robert Schaffer (second, Class II), E. H. Schaefer and Henry Koether (joint winners, first prize, Class II), L. N. Wallert, Elsie Claiborne (first, Class I), Richard Garber and Jim Augustine.

First-place winners in Twin City Section's contest, Francis Tillemans, Class II, Commercial (left in photo at far left) and Don Olson, Class I, Residential (left in photo at left) receive checks from ALC chairman, R. J. Graf. Mr. Tilleman's prize-winning lighting design was for a target range; Mr. Olson's, for a total electric home.

Winning entry in the Pittsburgh Section's Allied Arts Contest for the interior and lighting design of a motel lobby, entrance, service desk and private office will be incorporated into a new motel being built in State College, Pa. Judges of the entries submitted by Penn State University architecture students included four Penn State architecture professors, the chairman and secretary of the Pittsburgh Section and an official of the motel company. Shown here, l. to r.: Professor Vincent Pass; T. R. DeCoursey, representative of the motel; Professor Reis; R. L. Tuve, third-prize winner; W. C. Whitlatch, second-prize winner; J. B. McNall, chairman, Pittsburgh Section. First-prize winner, Lester Walker, is missing from photo.

Society. Sets of the 100 two- by two-inch colored slides may be purchased, if desired, for $25.

Street Lighting vs. Accidents New CIE Report Available

"Street Lighting and Accidents," a report prepared by a Committee of Experts (E-3.3.1) of the International Commission on Illumination is now available. The report summarizes an exhaustive study on the influence of street and highway lighting on the number of traffic accidents, conducted by the CIE committee of street lighting experts.

Designated as Publication No. 8, the report is 28 pages and is printed in French, English and German. Price is $2.00, with 40 per cent discount available to CIE members.

Orders for the report should be sent to Jean J. Chappat, Commission Internationale de l'Eclairage, Bureau Central, 57 rue Cuvier, Paris 5e, France.

Cleveland Satellite Night Coincides with Russian Space Flight

An amazing display of timing (or was it extra-sensory perception?) by Cleveland Section Chairman, Fred C. Winkler, brought members of the Section to the Sohio Research Center Satellite Tracking Center on April 12—the day the Russians announced Yuri Gagarin's orbital space flight. This timely scheduling of the Section's annual family night meeting (aranged earlier in the year) enabled IES members to be the first to hear Sohio's tape of the orbital flight.

In addition to the unexpected "scoop," the meeting included a tour of the Sohio (Standard Oil Co. of Ohio) Research Center and a lecture on satellites by Dr. A. Letcher Jones, head of the tracking station operation. Dr. Jones' talk was illustrated with pictures taken by Tyros satellites and recordings of satellite signals received by the station.

The Sohio tracking station, financed and equipped by the Research Center, is a voluntary operation staffed by 12 members of the Research Center staff who work after hours and on weekends to construct and operate the station. It has been in operation since the launching of Explorer I in 1958. Observations and recordings obtained at the station by mapping the "radio" sky contributed to the findings of the recent International Geophysical Year. All data collected is forwarded to the government.

CONTESTANTS and judges in the Chicago Section's Applied Lighting Competition. Names of first-prize winners in both classes of the contest will be inscribed on a plaque in the Chicago Lighting Institute.

ALC Plaque Presented to Chicago Lighting Institute

Winners of the Chicago Section's Applied Lighting Competition, beginning with 1961, will have their names inscribed on a bronze plaque at the Chicago Lighting Institute, as a result of the efforts of this year's Chicago ALC committee. The plaque, recently presented to Carl Zersen, president of the Chicago Lighting Institute, by Section ALC Chairman, Don Ingwersen, will contain the names, class and year of ALC first-prize winners. Names to be inscribed this year are Melvin Cohen for Class II and Harvey T. Sorenson for Class I.

The Chicago Section's promotion of the Applied Lighting Competition is among the best on the local level. Last year, a lighted window display in the local utility building featured photographs of ALC entries, contest rules and prizes.

Two Fluorescent Lamp Standards To Have Year's Trial

Two proposed American Standards for dimensional and electrical characteristics of 48- and 72-inch rapid-start fluorescent lamps will undergo a one-year trial period prior to their consideration, for final approval, by the American Standards Association. The use of the standards on the industrial level for one year is expected to provide the ASA Sectional Com-

SATELLITE NIGHT for Cleveland Section included a tour of Sohio Research Center laboratory and a talk by Dr. A. Letcher Jones, supervisor of basic research at the center. Shown here inspecting the center's tracking station, left to right in photo at left: Len Ickis, Monte Cutler, Mrs. Cutler, Mrs. Bill Kahler, Al Gaetjens, Bill Kahler. In photo at right, Jim Meacham, section chairman Fred Winkler and Dr. Jones enjoy after-dinner coffee.

ONE of nine weekly sessions in the basic lighting course conducted jointly by the IES San Jacinto Section and the Houston Lighting & Power Co.

mittee with data for full evaluation of the application and technical acceptability of the standards.

Developed by ASA Sectional Committee on Standards for Electric Lamps, C78, under the sponsorship of the Electrical Standards Board of ASA, both standards specify lamp designations, dimensional and operating characteristics and starting requirements for 48- and 72-inch, 1.5-ampere, T-12 and PG-17 rapid-start fluorescent lamps. The section on starting requirements covers single-lamp ballasts and ballasts for two and three lamps in series.

Copies of the proposed standards, C78.705 for 48-inch lamps and C78.706 for 72-inch lamps, may be obtained for 40 cents each from the American Standards Association, Department PR 228, 10 East 40th Street, New York 16, N. Y.

San Jacinto Lighting Course Attended by 102 in Houston

The third applied lighting course, co-sponsored by the San Jacinto Section of IES and the Houston Lighting & Power Co., was held from March 21 to May 23 in Houston, Texas. The course, which was last conducted in 1958, was revised this year to cover all the most recent developments in lighting, including new and improved light sources, improved methods of application, use of modern equipment and the higher illumination levels. Nine weekly sessions consisting of sound-slide films, lectures, demonstrations and discussion covered 19 areas of basic lighting design.

The 102 students registered for the course included 16 architects and engineers, 34 contractors, 24 supply house personnel and 30 lighting salesmen, students and others. Wayne Adams, chairman of the San Jacinto Education Committee, served as coordinator of the course, with various members of the Section acting as instructors.

Iowa Section Holds Spring Lighting Conference

Five home management students from the University of Iowa who participated in a residential lighting competition were the highlights of the Iowa Section's Spring Lighting Conference, held at the Hotel Kirkwood in Des Moines. The competition was planned under the direction of Dr. Mary Pickett who also addressed the meeting on the residential lighting program offered by the University. Two laboratory-lecture courses in lighting, one to prepare the students to be intelligent consumers of lighting, the other to train them for careers as residential lighting specialists, are conducted at the school.

In addition to this program on the teaching of residential lighting, the meeting included talks by Dave Owen, Westinghouse Electric Corp., on "The Challenge of Lighting for Safe Highway Travel," and by Jim McGeeny, Interstate Power Co., on "Applied Principles of Modern Mayhem."

1961—Active Organizational Year For Residence Lighting Forums

The Residence Lighting Forum program, an IES-sponsored activity which in some areas shows greater vigor than local Section/Chapter work, has seen a great surge in membership in recent months. Two new Forums affiliated with the Golden West Chapter have been organized in Regina and Yorkton, Sask., and a group of Academy of Lighting Arts graduates in Hamilton, Ont., have recently petitioned for the formation of a Niagara Forum. In addition to these, eight prospective Forums are reported developing in Canada in Saskatoon, Prince Albert, Melfort, Weyburn, Moose Jaw, Swift Current, Vancouver and Winnipeg. In the United States, groups in Cleveland and Little Rock are approaching charter status.

This increase in Forum activity has, in large part, been stimulated by the Academy of Lighting Arts, whose graduates look to the IES-sponsored Forums as sources of continuing contact with developments in lighting equipment and techniques. An announcement, by the Residence Lighting Forums Committee,

(Continued on page 14A)

COOPERATION between IES and the American Institute of Electrical Engineers on the local level. IES Montreal Section is conducting a course on lighting for the Montreal Section of AIEE. Shown here at the opening session of the course, l. to r.: Camille Labrecque, first lecturer; Andre Dandenault, chairman, IES Montreal Section Education Committee; H. O. Wilson, chairman, AIEE Section, Al Hanley, chairman, IES Section.

new SOLA outdoor mercury-lamp transformer

provides parallel protection

. . . plus constant-wattage stability!

Here's the big improvement you've waited for in *mercury lamp ballasting:* a really stable, *parallel-type,* constant-wattage, *2-lamp* transformer. Even if one lamp burns out, this new SOLA transformer keeps the other shining steadily.

And SOLA's *constant-wattage performance* protects both lamps and wiring against surge current . . . forestalls flicker by providing complete electrical independence between paired lamps; also, automatically compensates for line-power fluctuations. And the modest starting demand of SOLA constant wattage allows you to install more fixtures per circuit without having to step up wire sizes. The cost advantages are obvious in such installations as: parking lots, shopping centers, service stations, and dock areas.

Contact your SOLA representative for details on new 2-lamp outdoor constant-wattage MV transformers, as well as the other indoor and outdoor alternative units. Or write for information, mentioning *parallel MV outdoor transformer.*

- "Paralleling" ends double lamp-outages
- Exclusive constant-wattage design holds lumen output within ±1% for line-voltage changes as great as ±13%, assuring full-rated lamp life
- Prevents "drop-out" since input voltage must fall 30% below nominal before lamps extinguish
- Inherent protection against open or short-circuited lamps
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Installations in the News...

Engineered Lighting for Parking Garage

Specification of shielded luminaires for New York City's first municipal garage in the Brooklyn Civic Center was designed to prevent lamp pilferage, guard against breakage by automobile aerials and prevent dust collection on lamps. In addition to accomplishing these objectives, the prismatic crystal glass lenses engineered for the installation provide quality illumination—a nearly uniform lighting pattern at floor and eye level.

Four different lighting levels, achieved with varying arrangements of modular, 4-foot, 40-watt fixtures, were designed to meet a variety of lighting needs. Highest illumination level, 55 fc at the entrance to ease adaptation from daylighting to interior lighting levels, is produced by 5 continuous 40-foot long rows of fixtures arranged on 9-foot centers. Three 56-foot long rows on 9½-foot centers provide 30 fc in the transition area between entrance and parking locations. An illumination level of 5 fc for the aisles is obtained from a row of interspaced 8-foot fixtures mounted on each side of the aisle on 14-foot longitudinal by 15-foot transverse centers. Similar units arranged on 14- by 20-foot centers yield 3 fc in parking locations.

Photo and data are courtesy of Holophane Co., Inc., New York, N. Y. and McPhilben Manufacturing Co., Inc., Brooklyn, N. Y.

(Continued from page 12A)

of $100 subsidies toward operational expenses for the first five groups organized this year, might also be responsible for this potential doubling of the number of Forums during 1961.

ABOUT PEOPLE

Parenthetical designations denote membership grade in the Society.

The election of **George Pope** as vice-president of manufacturing at the Cicero, Ill., pole line hardware plant of Hubbard and Co. has been announced by the firm's board of directors. Formerly manager of Metal and Thermit Corp. plants in Chicago and New Jersey, Mr. Pope joined Hubbard in 1959. The board of directors also elected **John C. Monday** as vice-president and general manager of Hubbard's Hapco Division, Pittsburgh, Pa. In his new position, Mr. Monday will be responsible for production, sales, engineering and related functions for the division. Other Hapco Division announcements named **Matt Anderson** as chief industrial engineer and **James Lucas** as plant foreman.

Curtis-AllBrite Lighting, Inc., Chicago, Ill., has announced the appointment of **Joseph R. Ray** to the position of vice-president in charge of sales. Mr. Ray was formerly general sales manager for the company. Also announced was the promotion of **Irvin Wescott** from advertising manager to director of marketing. In addition to his new marketing duties, Mr. Westcott retains the responsibility for Curtis-AllBrite's national advertising program.

The appointment of **James P. Kennedy** (A) as vice-president of Merchandising Advertisers, Inc., Mount Prospect, Ill., has been announced by Fred Ohlrich, president of the firm. Prior to joining Merchandising Advertisers, Mr. Kennedy was associated with the Sola Electric Co., Chicago, Ill.

Sam F. Blake, Jr. has been promoted to vice-president of eastern sales for the Luxo Lamp Corp., Port Chester, N. Y., according to an announcement by T. Torsen, president of the company. Prior to assuming his new position, Mr. Blake served for three years as eastern sales manager.

J. D. Whitnell (M) has been named manager of commercial and industrial market development for the Arizona Public Service Co., Phoenix, Ariz. Formerly, he served the company as commercial sales engineer.

Edward D. Frye has joined the staff of the Edison Electric Institute, New York, N. Y., and has been assigned to national defense matters and related subjects. In addition to serving as secretary to the EEI Task Force on National Defense, Mr. Frye will assist in special studies conducted by the Institute.

Twelve additional companies have recently joined the National Electrical Manufacturers Association, according to an announcement by Joseph Miller, NEMA managing director. The new member companies are: Aluminum Co. of America, Pittsburgh, Pa.; American Electric Manufacturing Corp., Memphis, Tenn.; The Dahlberg Co., Minneapolis, Minn.; Diamond Expansion Bolt Co., Inc., Garwood, N. J.; The Ebco Manufacturing Co., Columbus, Ohio; Harvey Aluminum, Inc., Torrance, Calif.; Hatfield Wire & Cable Division, Continental Copper & Steel Industries, Inc., Hillside, N. J.; The Puritron Corp., New Haven, Conn.; H. H. Robertson Co., Pittsburgh, Pa.; Royal Electric Corp., Pawtucket, R. I.; Swan Manufacturing Co., Vancouver, Wash.; Wabash Magnetics, Inc., Wabash, Ind.

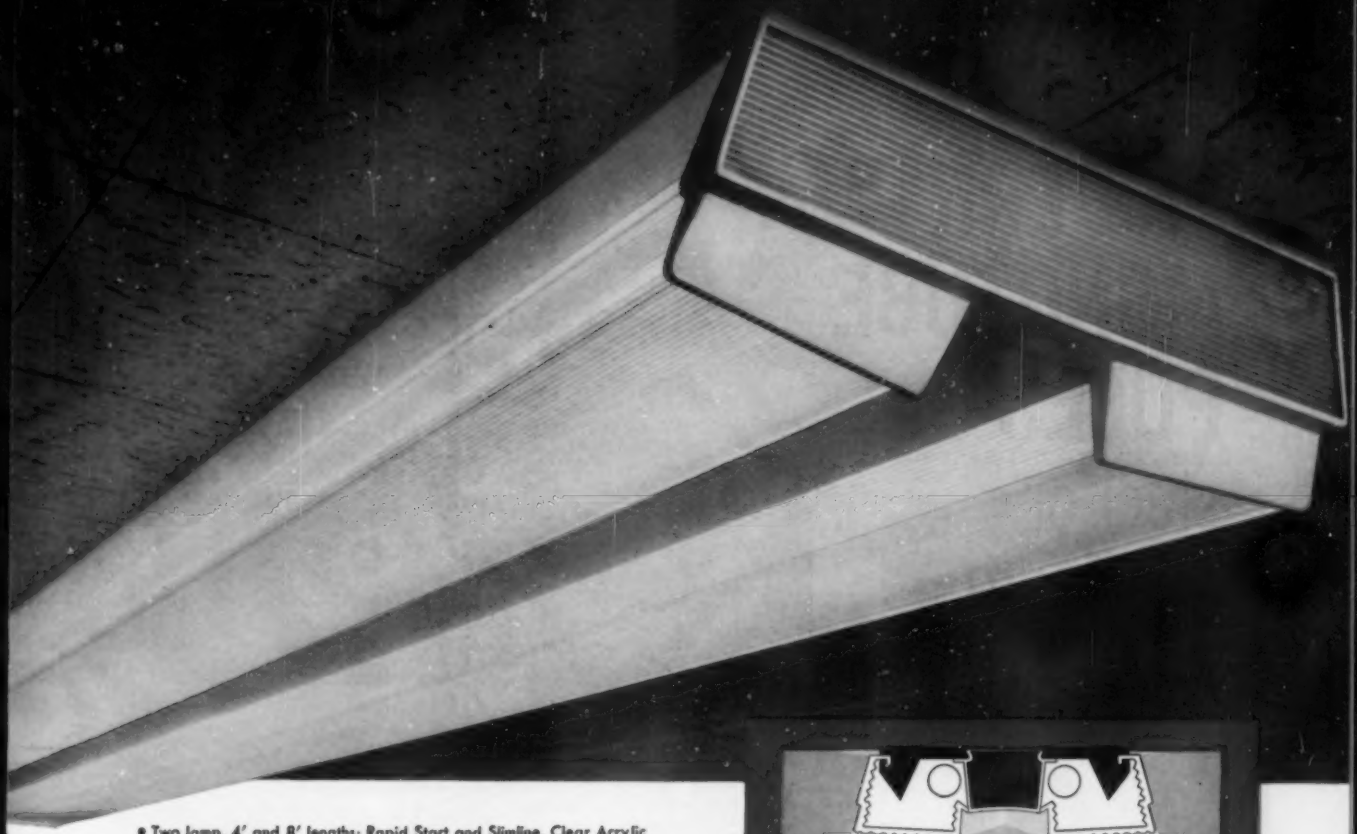
Two new appointments in the Lighting Products Division of Sylvania Electric Products Inc., Salem, Mass., have been recently announced. **Frederick R. Smith,** named as manager of customer service, will be responsible for the Warehouse Distribution Department and provide liaison between sales and corporate warehouse personnel and management. In addition, he will continue to serve as supervisor of inventory control, a position he has held for the past year. **Jerry R. Schmitt** (A), previously divisional senior

(Continued on page 17A)

More seeing comfort by design . . .

NEVER BEFORE, SO MUCH SEEING COMFORT AT SO LITTLE COST *in a Plastic-enclosed Fluorescent Fixture for Surface Mounting*

Duplex-a-lite®
LIGHTING by miller



- Two lamp, 4′ and 8′ lengths; Rapid Start and Slimline. Clear Acrylic or light stable Polystyrene lenses. 13⅛″ width.
- Self Hinging Plastic Enclosure for Each Lamp supported on both edges by continuous flanges in channel—Easy to Maintain—No Sag.
- Cooler Lamp and Ballast Operation—each lamp has its individual compartment widely separated by exposed metal channel which acts as a heat dissipator.

This altogether new and different looking fixture is a precision lighting tool, optically designed for optimum *seeing comfort* and economy . . . a performance feature we call Opticomfort. Duplex-a-lite controls and evenly distributes the right amount of the right kind of light where it's needed most . . . puts more usable light on the work or merchandise—less in the eyes. It is especially suitable for schools, offices, public buildings and stores . . . wherever there's a need for *seeing comfort* over prolonged periods of time.

A truly unique combination of fresh, trim appearance and *seeing comfort* at a *modest* price . . . a natural for on-the-ceiling mounting in newer buildings where ceilings are low.

For complete information, write Dept. 661 S, or contact your Miller Representative.

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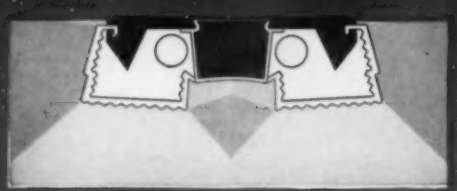


*Opticomfort** BY DESIGN

Another Miller First! Twin compartments separate and house each of Duplex-a-lite's two lamps in a unique manner that enables the optically designed, prismatic lenses to limit and control most of the light within the highly critical 45°-90° viewing zone. This assures optimum seeing comfort, or Opticomfort. Ceiling and center channel cover are softly illuminated. Enclosures of rigid plastic require no shadow-causing interior framework.

*Trademark Patent Pending

LIGHTING BY miller SINCE 1844

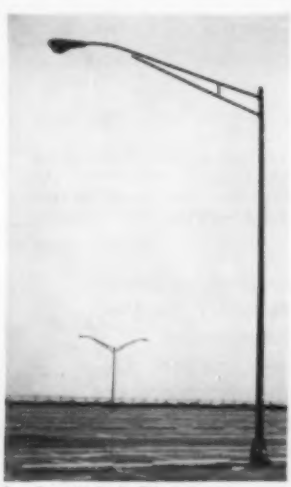
THE **miller** COMPANY
MERIDEN, CONNECTICUT • UTICA, OHIO

plan your lighting with **MODERN MONOTUBE POLES** steel or aluminum

Airports

Shopping Centers

Schools



Industrial Plants

Roadway Plazas

UNION METAL

THE UNION METAL MANUFACTURING COMPANY

Canton 5, Ohio Brampton, Ontario

Monotube Area Lighting Poles

(Continued from page 14A)

sales representative at Sylvania's Seattle office, has been appointed as an assistant product manager.

Recently appointed to the metropolitan New York sales region of the Union Carbide Plastics Co. were **E. Warner Emmens** as office manager and **W. Warren Swenson** as special representative. Both men will be located in the company's Clifton, N. J. office. Also announced by Union Carbide was the appointment of **George H. Dougherty, Jr.** as technical representative in the midwestern sales region. Mr. Dougherty will be headquartered in Chicago.

The Electrolier Manufacturing Co., Ltd., Montreal, Que., has announced the appointment of **R. R. Champagne** (A) as district manager for western Canada. With headquarters in Regina, Sask., Mr. Champagne will be responsible for the sales promotion and distribution of Electrolier products throughout the provinces of Manitoba, Saskatchewan, Alberta and British Columbia.

According to an announcement by W. C. Goodwin, southwestern district manager for The Bryant Electric Co., Bridgeport, Conn., **John R. Commons** has been named sales representative for the concern's Houston territory. Formerly, Mr. Goodwin served as power consultant for the Houston Lighting and Power Co., Houston, Texas.

A number of new appointments by the Corning Glass Works, Corning, N. Y., include **John R. McLaughlin** and **George Weinhold** (A) as Pittsburgh district salesmen for the Technical Products Division. Mr. McLaughlin will represent the company's Plant Equipment and Lighting Glassware Departments in western Pennsylvania, eastern Ohio and West Virginia; Mr. Weinhold, from headquarters in Detroit, will cover the eastern Michigan, western Ohio and eastern Kentucky territory. **Robert J. Hull** has been appointed supervisor of customer service for the central sales district of the Technical Products Division and **R. Bruce Martin** has been named to represent the Lighting Glassware Department in the Chicago north area.

The Swivelier Co., Inc., has announced the appointment of **Goren/Newman, Inc.,** as manufacturers representatives in New York City.

The appointments of two sales representatives have been announced by The Bryant Electric Co., Bridgeport, Conn.

(Continued on page 18A)

SCHEDULED EVENTS

1961 Dates of Interest to IES Members

June

June 18-23—American Institute of Electrical Engineers, Summer General Meeting, Ithaca, N. Y.

June 19-20—Great Lakes Regional Conference, IES, Sheraton-Gibson Hotel, Cincinnati, Ohio.

June 26-28—American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Denver-Hilton Hotel, Denver, Colo.

July

July 4-7—National Society of Professional Engineers, Annual Meeting, Olympic Hotel, Seattle, Wash.

July 18-20—Western Plant Maintenance Show, Pan Pacific Auditorium, Los Angeles, Calif.

August

August 21-23—National Association of Lighting Maintenance Contractors, National Convention, Flamingo Hotel, Las Vegas, Nev.

August 22-25—Western Electronic Show and Convention, Cow Palace, San Francisco, Calif.

September

September 12-15—Industrial Building Exposition, New York City Coliseum, New York, N. Y.

September 14-15—Engineering Management Meeting, sponsored by AIEE and ASME, Hotel Roosevelt, New York, N. Y.

September 24-29—Illuminating Engineering Society, National Technical Conference, Chase-Park Plaza Hotel, St. Louis, Mo.

October

October 4-6—Canadian Electrical Manufacturers Association, Annual Meeting, Sheraton-Brock Hotel, Niagara Falls, Ont.

October 4-6—International Association of Electrical Leagues, Annual Conference, President Hotel, Atlantic City, N. J.

October 9-10—United States National Committee, CIE, Annual Meeting, Olentangy Inn, Columbus, Ohio.

October 9-11—Annual National Electronics Conference, International Amphitheatre, Chicago, Ill.

October 10-12—American Standards Association, National Conference on Standards, Rice Hotel, Houston, Texas.

October 10-13—National Electrical Contractors Association, Annual Convention and Exposition, Washington, D. C.

October 15-20—American Institute of Electrical Engineers, Fall General Meeting, Detroit, Mich.

October 18-20—Optical Society of America, Annual Meeting, Biltmore Hotel, Los Angeles, Calif.

November

November 16—National Electrical Manufacturers Association, Annual Meeting, New York, N. Y.

Register Early for National Conference

Registration forms will be mailed to all members later this month for the National Technical Conference, September 24-29, in St. Louis, Missouri.

Watch for this, and register early. A splendid program has been planned for the Conference. Details of it are shown on pages 5A through 8A of this issue.

Register Early

FIRST honorary member of the Lamplighters of America, Norman R. Sutherland (right), president of the Pacific Gas and Electric Co., lights symbolic gas street lamp. Shown here with Mr. Sutherland are charter officers of the Lamplighters, l. to r.: B. B. Howard, chairman-elect; Harry Edwards; R. E. McKillican; J. H. Burson, charter chairman; G. A. Trosper. The Lamplighters, an organization devoted to the promotion of safer nighttime travel, was founded in the street lighting committee of the IES Golden Gate Section. Other local groups are now being formed throughout the country.

(Continued from page 17A)

Harlan D. Lawson will be responsible for the company's sales and service activities in the Detroit territory and **Byron L. Waters** will cover the Los Angeles territory, comprising Arizona and part of southern California.

Death

A. J. Lucier, Michigan Section.

BOOKS AND PAMPHLETS

Books marked * may be inspected in the Technical Office at Headquarters.

Fluorescent Lighting Manual, Third Edition,* by Charles L. Amick, published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y., 1961, 416 pages, 244 illustrations, indexed, $12.50.

This practical guide to design, installation, and repair of fluorescent lighting systems, which first appeared in 1942 shortly after fluorescent lamps were introduced commercially, has again been published in a new and up-dated edition.

Lamp data, operating principles, auxiliary equipment, methods of installation, color information, and typical applications are described, as well as procedures to follow for designing general and supplementary lighting systems, selecting appropriate fluorescent-lamp luminaires and analyzing and correcting service problems. Treatment is given to the economics of lighting, including a comparison of the cost factors of fluorescent and incandescent lamps.

In addition to providing information on the latest advances in wiring methods, materials, and control devices, this edition covers developments in high-output and extra-high-output lamps, and gives modern classifications of ceiling-suspension systems, with methods of installing recessed equipment for each.

The author is Director of Research and Development at Day-Brite Lighting, Inc., St. Louis, Mo. His technical background also includes a long association with the application engineering and product planning group at General Electric.

Units of Weights and Measures (United States Customary and Metric) —Definitions and Tables of Equivalents, National Bureau of Standards Miscellaneous Publication 233, 1960, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 20 pages, 40 cents.

This publication, which supersedes Miscellaneous Publication 214, was developed as a result of a 1959 agreement among directors of national standards laboratories in English-speaking nations to obtain uniformity in precise measurements involving the yard and the pound.

Units of length, area, volume, capacity and mass in the United States are defined in conformity with the 1959 agreement and tables of interrelation and equivalents for these units in the metric system and the U. S. customary system have been recalculated by automatic computer. Further revisions contained in the booklet include the deletion of the table showing the interrelation between bushels and hectoliters and the addition of a more complete table for equivalents of inches in millimeters.

The Consulting Engineer, by C. Maxwell Stanley, published by John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. $5.95.

The management and professional problems of a consulting engineering practice form the subject of this book, authored by a practicing consulting engineer who is senior partner and general manager of the Stanley Engineering Co.

The consultant's professional relationships to clients, other companies and the public, internal organization details of personnel, facilities, procedures and management are examined in detail to provide the reader with a practical guide for the operation of his business. The author also discusses tax angles, labor benefits, relative merits of a partnership or corporation for the consultant's practice, budget balancing and the details of day-to-day office operation.

Seeing Colors,* by J. Bergmans, published by the Macmillan Co., 60 Fifth Ave., New York 11, N. Y., 1960, 80 pages, illustrated and indexed, $3.00.

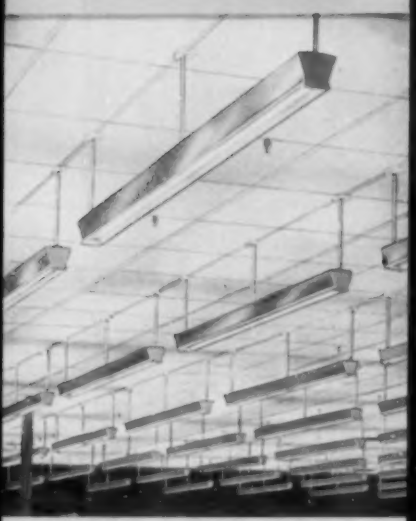
This book is intended to give a concise general treatment of color vision. The author hopes that grammar school teachers will introduce their students to its contents.

Subjects covered in this Dutch book include: the physical properties of light; color vision; color triangles; color temperature; and color rendition. One of the two color plates shows a comparison of the color rendition of several different light sources.

Handbook of Chemistry and Physics, Forty-Second Edition, Charles D. Hodgman, Editor-in-Chief, published by The Chemical Rubber Publishing Co., 2310 Superior Ave., N.E., Cleveland, Ohio, 1960, 3481 pp., indexed, $12.00.

This Handbook, a well-known single volume reference on mathematics, physics and chemistry, has been revised and brought up to date to include new data and delete obsolete information. Where necessary, tables have been either entirely or partially revised.

(Continued on page 20A)



Autonetics
A Division of North American Aviation
LOK-Electric Series 3000
Pendant Fixtures (1500 M. A.)

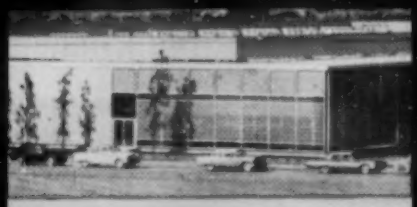
Architect: Bechtel Corporation
General Contractor: Lindgren & Swinerton
Electrical Contractor: Carsten Electric

Collins Radio
LOK-Electric Series 2000
Two-lamp 12" wide
Recessed fixtures

Architect: A. C. Martin & Associates
General Contractor: Alpha Construction Co.
Electrical Contractor: Harman Electric

Representation:
Atlanta, Chicago, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, St. Louis, Salem (Mass.), San Francisco

Export:
Roldan Products Corp., St. Louis



K-LITE®

PLASTIC PRISMATIC LENS PANELS

Installed in

LOK-ELECTRIC

LIGHTING SYSTEMS

Manufactured by

LOK-PRODUCTS CO.
5109 San Fernando Road West
Los Angeles 39, California

The smooth flat surfaces and extra sharp edges of K-LITE® plastic prismatic lens panels provides the CONTROLLED lighting area specified for these buildings.

In addition, the superior qualities of the K-LITE® series offers:

greater strength than lenses of conventional material

more rigid because of prism pattern over entire panel regardless of size

no fade-outs. The top quality of acrylic and polystyrene guarantee years of even lighting.

LOOK TO K-S-H FOR NEW PRODUCTS THROUGH "PIONEERED ENGINEERING"

COMING...NEW PRISMATIC K-8

KSH

Litton Industries
LOK-Electric Series 3000
Pendant Fixtures (1500 M. A.)

Architect: A. C. Martin & Associates
General Contractor: C. L. Peck
Electrical Contractor: Newberry Electric

CHECK YOUR CATALOG SUPPLY AND SEND FOR THESE IMPORTANT ENGINEERING HELPS FROM K-S-H

Comprehensive Plastic Lighting catalog complete with coefficients of utilization, distribution charts, brightness data, etc.

Lighting Panel Area Calculator permits fast, accurate determination of square footage necessary for any lighting job.

K-LITE® sample panels. See and test yourself the superior quality of K-LITE® lens panels.

K-S-H PLASTICS, INC.
10212 Manchester
St. Louis 22, Missouri
(our new address)

(*Continued from page* 18A)

There are five indexed sections: Mathematical Tables; Properties and Physical Constants; General Chemical Tables; Heat and Hygrometry, Sound, Electricity and Magnetism and Light; Quantities and Units and Miscellaneous. The 286-page portion on light includes tables on such topics as: source efficiency and brightness, spectroscopy, emission spectra of the elements, index of refraction, reflectance, transmittance and fluorescence.

NEW MEMBERS

At the meeting of the Board of Examiners on May 10, 1961, the following were elected to membership. Names marked ° are transfers from Associate Member grade.

CANADIAN REGION

Bluenose Chapter

Member:
Mitchell, C. R., Mitchell Optometrists, Truro, N. S.

Forest City (London) Chapter

Associate Member:
Kirwan, L. J., C & M Products Ltd., Toronto, Ont.

Golden West Chapter

No Elections

Hamilton Ontario Chapter

No Elections

Maritime Chapter

No Elections

Montreal Section

Associate Members:
Boivin, C., Sylvania Electric (Canada) Ltd., Montreal, Que.
Majury, H., Southern Canada Power Co., Ltd., Montreal, Que.
Patterson, W. L., Peerless Electric Ltd., Montreal, Que.
Rang, F. W., Canadian Design Service Co., Montreal, Que.

Northumberland Chapter

No Elections

Ottawa Section

No Elections

Quebec Chapter

Member:
°Dunnigan, G. G., Northern Electric Co., Trois Rivieres, Que.

St. Maurice Valley Chapter

No Elections

Toronto Section

Members:
Whitehead, A., Canadian General Electric Co. Ltd., Toronto, Ont.
°Albini, C., C. L. M. Industries, Toronto, Ont.
°Wright, D. C., Canadian General Electric Co. Ltd., Toronto, Ont.
Associate Members:
Hartviksen, N. A., Yost-Keen & Associates, Toronto, Ont.
Holt, A. S. W., Midland Public Utilities Commission, Midland, Ont.
Hughes, S. D., John B. Parkin Associates Ltd., Don Mills, Ont.

Winnipeg Chapter

Associate Members:
Chester, C., Building Maintenance Co., Winnipeg, Man.
Wicks, S. G., The University of Manitoba, Winnipeg, Man.

EAST CENTRAL REGION

Capital Section

Member:
Karpe, S. F., Kluckhuhn & McDavid Co., Washington, D. C.

Eastern Pennsylvania Section

Associate Members:
Anthony, F. L., Pennsylvania Power & Light Co., Allentown, Pa.
Jones, D. T., Jr., Pennsylvania Power & Light Co., Harrisburg, Pa.
Price, A. F., Pennsylvania Power & Light Co., Allentown, Pa.

Maryland Section

Associate Member:
Webb, F. R., Jr., General Electric Co., Baltimore, Md.

Philadelphia Section

Member:
°Wivel, W. V., General Electric Co., King of Prussia, Pa.
Associate Members:
Abruzzi, E., Abruzzi Design, Philadelphia, Pa.
Buttling, W. J., Jr., General Electric Co., King of Prussia, Pa.
Ganaworth, L. B., 2137 Spruce St., Philadelphia, Pa.
Schmidt, A. R., Jr., A. Ernest D'Ambly, Consulting Engineer, Philadelphia, Pa.

Pittsburgh Section

Associate Member:
Oughton, W. J., Harry Ray Nay, Wheeling, W. Va.

Virginia Section

Associate Members:
Beveridge, D. D., Lustra Corp. of America, Long Island City, N. Y.
Graves, W. H., Graves Supply Co., Inc., Martinsville, Va.

GREAT LAKES REGION

Buckeye Chapter

Associate Members:
Ewing, R. L., Holophane Co., Inc., Newark, Ohio.
Leesman, J. C., C. J. Leesman Sales Co., Inc., Columbus, Ohio.
Oakwood, H. V., Jr., Graybar Electric Co., Inc., Columbus, Ohio.

Central New York Section

Member:
Bonk, J. A., Corning Glass Works, Corning, N. Y.
Associate Members:
Black, G. L., New York State Electric & Gas Corp., Ithaca, N. Y.
Goebert, K. E., New York State Electric & Gas Corp., Newark, N. Y.

Cleveland Section

Member:
°La Pelle, W. B., Sylvania Electric Products Inc., Cleveland, Ohio.
Associate Members:
Kuhn, E. W., Fostoria Corp., Fostoria, Ohio.
Rothenberg, H. W., Timely Lighting Products Inc., Cleveland, Ohio.

Kentuckiana Chapter

No Elections

Miami Valley Section

Associate Members:
Clark, J. E., Dayton Power & Light Co., Dayton, Ohio.
De Brosse, C. J., Dayton Power & Light Co., Dayton, Ohio.
Harvey, H. D., General Electric Supply Co., Dayton, Ohio.
Hudson, S. A., W-W Electric Co., Springfield, Ohio.
Knipp, F. R., Dayton Power & Light Co., Dayton, Ohio.
Lagedrost, H., Lagedrost & Walter, Dayton, Ohio.
Larkin, R. H., M. D. Larkin Co., Dayton, Ohio.

Michigan Section

Members:
°Davidson, C. A., Thermotank, Inc., Detroit, Mich.
°Wolf, S. B., Day-Brite Lighting, Inc., Detroit, Mich.
Associate Members:
Blosser, J. A., Owen Electric Supply Co., Flint, Mich.
Kirk, D., Owen Electric Supply Co., Flint, Mich.
Lastar, K. S., Lastar Electric Co., Detroit, Mich.

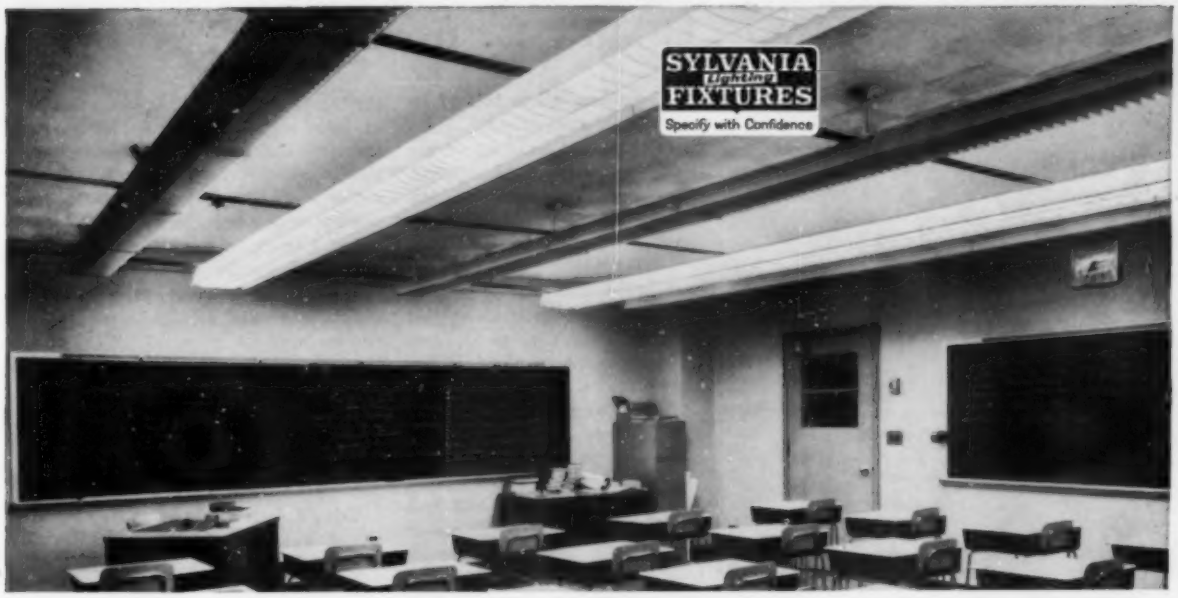
(*Continued on page* 23A)

Complete Tables of IES Recommended Levels Now Available in Handy Booklet Form

The entire recommended levels of illumination section of the *IES Lighting Handbook*, Third Edition, is now available in a 16-page, six- by nine-inch booklet. This publication, which lists all tasks covered by IES recommendations, replaces the 1958 "Recommended Levels in Current Practice" which contained a partial listing of the post-Blackwell IES minimum illumination standards.

Costs of the booklet are: 1 to 9 copies, 20 cents each; 10 to 99 copies, 15 cents each; 100 or more copies, 10 cents each. Imprinting of company name and address (minimum order 500 copies) is available at the nominal charge of $10 for four lines of type on 500 copies and $1.00 per hundred for additional hundreds.

Orders for the booklet should be sent to: Publications Sales Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.



SYLVANIA'S SCOTT FIXTURE

Passes Final Exam at Lancaster High School!

School authorities at Lancaster High School, Lancaster, New York, conducted a unique test recently to determine for themselves if Sylvania's SCOTT Lighting Fixture performed as well as claimed.

Three rows of conventional fixtures with normal spacing and mounting height were installed in one of the classrooms. *Two* rows of High Output SCOTT Fixtures were mounted in the same room.

LOOK AT THE GRADES OF THIS LIGHTING EXAMINATION!

Sylvania's SCOTT Fixture		Conventional Lighting Fixture
6 (8' length)	No. of units	9 (8' length)
2	No. of rows	3
1470 watts	Power consumed	1656 watts
104,400	Total lumen output	104,400
60 footcandles	Averaged *measured* quantity of illumination	47 footcandles

The lighting performance of each set of fixtures was then measured independently.

The result: *Two* rows of SCOTT Fixtures outperformed *three* rows of conventional fixtures in every practical way. The SCOTT provided more overall illumination. The use of fewer fixtures resulted in lower initial cost, operating cost and maintenance cost. (See table.)

The esthetic advantages of the SCOTT were shown in the same test. The majority of the room occupants definitely preferred the lighting and appearance of the SCOTT.

The SCOTT, with its economy, performance, attractiveness and choice of white or eye-rest green shielding, has proved the ideal fixture for many schools.

Full descriptive and technical information will gladly be sent on request.

SYLVANIA LIGHTING PRODUCTS
A Division of SYLVANIA ELECTRIC PRODUCTS INC.
One 48th Street, Wheeling, West Virginia

SYLVANIA

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

LIGHTING ITEMS . . . from all over

Interesting items about light turn up in numerous magazines—lay and technical—and on pages of newspapers everywhere. A few of these have been culled for this column. Others, as our readers spot them from time to time, will be received by IE with thanks.

Seeing Around Curves

An ingenious way to transmit images around corners has been discovered, and a whole new American industry is being born. The trick is done by means of a snakelike "fiber optics" pipeline made up of thin glass fibers put together in a slender, flexible, cablelike bundle. One end of the pipeline is pointed at the subject. Each individual fiber picks up from the subject a tiny dot of light which is transmitted intact along the fiber. At the other end of the bundle, the mosaic of dots forms an image.

The principle upon which fiber optics is based is an old one. Light passing through a medium like glass or water will, if it strikes the surface at a certain angle, bounce back instead of coming through—as it does through a window, for example. In a glass fiber, once light is trapped, it keeps bouncing from wall to wall until it comes out the other end. This neat laboratory trick has burgeoned into a thriving little industry whose fast-growing list of new products seems likely to turn it rapidly into a thriving big business. FROM: *U. S. Business Week.*

Space-Test Eye

Any system to detect clandestine atom bomb tests must consider tests in space. A nuclear burst in a vacuum does not form a bright fireball; it gives off very little visible light and even if it were as near as the moon, its flash might be too feeble to attract unalerted attention. . . . Detecting such a test is not impossible . . . given the right instruments. On a roof at Los Alamos Scientific Laboratory, six wide-angle lenses stare day and night at the sky. Each is linked to a filter that makes it blind to all light except a special kind that comes from the fluorescence of nitrogen or oxygen. If light of this unusual sort comes down from the sky, the rooftop apparatus at Los Alamos will ring an alarm that will sound around the world. It will mean that some nation has attempted a secret bomb test in space—and has been caught.

The U. S. tests above the atmosphere in 1958 taught that when a nuclear bomb explodes in a vacuum, about half of its energy goes into invisible M rays. These hit the atmosphere and make its oxygen and nitrogen fluoresce in characteristic wave lengths that can easily be distinguished from the spectrum of sunlight. When Los Alamos physicist Donald R. Westervelt learned about this, he designed a detection system based upon it. A few dozen of his detectors spotted around the earth would be an adequate network. Some of them would always be under clear skies. In daylight they would detect a one-megaton burst two million miles from earth, farther at night. Cost of each station: $100,000.

A problem still remaining is to prove that no natural phenomenon will look like a space test to Westervelt's detectors. The model at Los Alamos has already passed one test: it is not fooled by lightning. Further tests at Fairbanks, Alaska will see whether it cries a false bomb scare when a strong aurora shines in the night sky. Only if it can distinguish a nuclear explosion from all natural events will the detector be recommended for international test watching. FROM: *Time* Magazine, November 7, 1960.

Improved Sight for "Electronic Eyes"

Development of a new photoemissive material that permits "electronic eyes" to operate at high temperatures was announced recently by the Westinghouse Electronic Tube Division. The search for a more versatile photometer which translates light into electric signals, was conducted by Westinghouse for the U. S. Navy, Bureau of Ships, as part of the long-range supporting research program of the Department of Defense. Photoemission provides the operating principle for many photoelectric tubes, including television camera tubes and light amplifiers.

Dr. W. H. McCurdy, manager of the Division's applied research department, said the new photoemitter can considerably improve the reliability of light-sensing devices for space vehicles and other equipment that must operate under high-temperature conditions.

Chief advantage of the new photoemitter is its ability to function efficiently for long periods at temperatures twice the range of present types. In addition, its high sensitivity allows it to operate at low light levels. Dr. McCurdy reported that tests on the new material show excellent stability when operated as long as 140 hours at 120°C—well above the boiling point of water. "Other photoemissive surfaces begin deteriorating at about 60°C," he said, "and they suffer a large loss in sensitivity after 100 hours at the 120-degree level." The new photoemitter uses a semi-transparent combination of antimony, potassium, and sodium deposited as a thin semi-transparent layer on glass. Light striking the layer causes the material coating to release electrons which generate electric signals. FROM: *Electrical Engineering.*

Light Helps Measure Mile

Using reflected light rays, U. S. Coast Guard and Geodetic Survey scientists have succeeded in measuring 50-mile distances to an accuracy within the "width of a toothpick" per mile.

Precise measurement of the distance between tracking stations has been one of the major problems in testing rockets and missiles in recent years. Without knowing exactly how far each tracking camera is from the ground zero, it is impossible to calculate, at any given moment, the missile's position and trajectory. Yet this must be known at all times both for safety and for development of of the rocket system.

Exact distances between the nine launch-tracking cameras used at Cape Canaveral have now been worked out. Researchers admit that they would probably not have been so successful except for the flatness of the Florida terrain and the area's reasonably uniform temperatures. They are immensely proud, however, that they were not only able to accomplish the job but also to cut Air Force tolerances in half.

The key instrument used in the calculations was a geodimeter—an instrument that can measure up to around 25 miles by flashing a light from the point and having it reflected back to a prism at the target point. Knowing the speed of light (186,000 miles per second), an operator can then figure the distance between the points by the time it takes light to make a round trip between them.

To minimize atmospheric interference in taking measurements, scientists mounted a geodimeter on top of a mobile 90-foot tower. A similar tower was used to lift the target prism above the ground haze. The geodimeter, developed in Sweden, was brought to the U. S. for experimentation only three years ago. FROM: *U. S. Business Week.*

Installations in the News...

High-Output Lamps for Sign Spectacular

Lighting for this 70-foot high double-faced plastic sign, recently erected above a Standard Oil Co. service station in St. Louis, is from a combination of 660 high-output fluorescent lamps and 96 floodlamps. Fluorescent lamps alone are used in the 50- by 40-foot oval portion of the sign with the combination applied to the torch at top. Lamps are powered by two-lamp, 800-ma, rapid-start flasher-type ballasts with 300 contact points in the flasher. Flasher control for the torch lighting creates a flickering flame effect.

The sign, which reproduces the company's emblem in red, white and blue Plexiglas, is supported by a steel structure. It is completely weatherproof and insectproof and is cooled by a thermostatically controlled ventilating system. Blowers in the flame section dissipate the heat generated by the floodlamps.

Photo and data courtesy of Jefferson Electric Co., Bellwood, Ill.

(*Continued from page* 20A)

NORTHWESTERN OHIO SECTION

Associate Members:
Artopoeus, J., Artopoeus Sales Co., Toledo, Ohio.
Losie, M. J., Verd-A-Ray Corp., Toledo, Ohio.

OHIO VALLEY SECTION

Associate Member:
Simms, R. R., Henry Elden & Associates, Architects & Engineers, Charleston, W. Va.

ROCHESTER SECTION

No Elections

WESTERN MICHIGAN SECTION

No Elections

WESTERN NEW YORK SECTION

Associate Members:
Aldrich, R. P., Wide Lite Corp., Eggertsville, N. Y.
Baker, W. R., New York Telephone Co., Buffalo, N. Y.

INTER-MOUNTAIN REGION

ARIZONA SECTION

Associate Member:
Mauran, O., Arizona Public Service Co., Flagstaff, Ariz.

NEW MEXICO CHAPTER

Associate Members:
Isbell, T., Bynum, Dinsmoor & Isbell, El Paso, Texas.
Lawrence, B. W., State Electric Supply Co., Albuquerque, N. M.

ROCKY MOUNTAIN SECTION

Associate Member:
Conrad, C. S., P. O. Box 6775, Denver, Colo.

SOUTHERN COLORADO CHAPTER

No Elections

UTAH SECTION

No Elections

MIDWEST REGION

CENTRAL KANSAS CHAPTER

No Elections

CORNHUSKER SECTION

No Elections

HEART OF AMERICA SECTION

No Elections

ILLINI CHAPTER

Associate Members:
Bledsoe, H. C., Bledsoe Electric, Decatur, Ill.
Boland, R. J., Boland Electric Supply Co., Decatur, Ill.
Evans, K. B., Central Illinois Public Service Co., Mattoon, Ill.
Kepp, W. B., Central Wholesale Supply Co., Mattoon, Ill.

IOWA SECTION

No Elections

OZARK CHAPTER

No Elections

ST. LOUIS SECTION

Associate Members:
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Dygert, H. B., Jr., Horner & Shifrin, Consulting Engineers, St. Louis, Mo.
Lloyd, F. E., Champion Lamp Works, St. Louis, Mo.

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Borre, E. M., Cooley & Borre & Associates, Park Ridge, Ill.
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Madden, J. J., Kelsho-Burnett Electric Co., Chicago, Ill.
Nixon, J. H., Maron Electric Co., Chicago, Ill.
Reid, E. S., Contact Electric Supply, Inc.,
Tevenan, J. C., Electric Supply Corp., Chicago, Ill.

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No Elections

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No Elections

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No Elections

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Marshall, H. E., Harvey Hubbell Inc., Bridgeport, Conn.
Safford, J. W., Holmes Ave., Darien, Conn.

(*Continued on page* 38A)

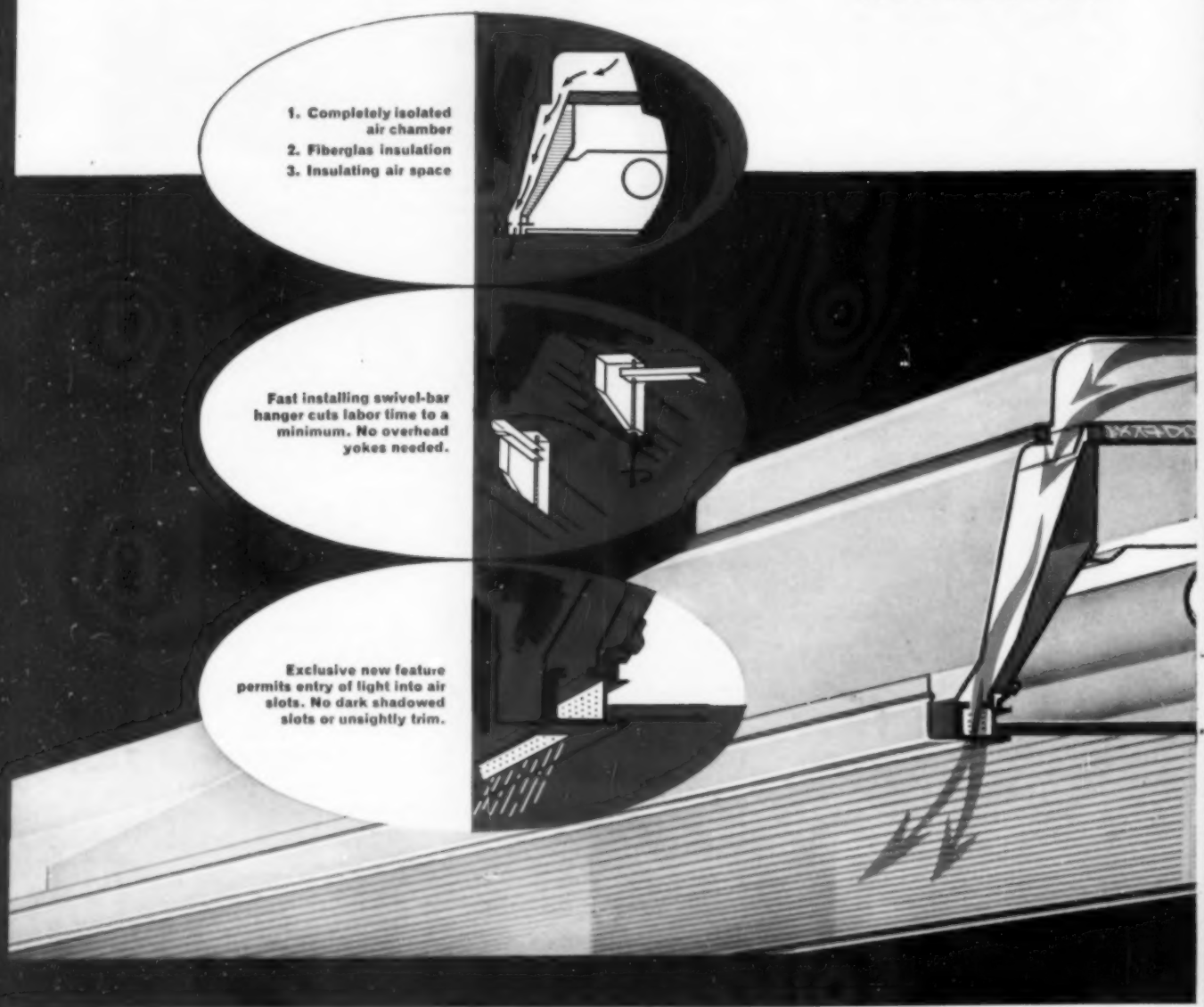
greatest advance yet in air-handling troffers

the all new **TRIPLE–**

LIGHTS HEATS COOLS

with air capacity range never before possible...

(NOW 0-200 CFM)


1. Completely isolated air chamber
2. Fiberglas insulation
3. Insulating air space
Fast installing swivel-bar hanger cuts labor time to a minimum. No overhead yokes needed.
Exclusive new feature permits entry of light into air slots. No dark shadowed slots or unsightly trim.

THOMAS INDUSTRIES INC.

the world's largest single source of lighting for

SHELL Lumi-flo

by BENJAMIN

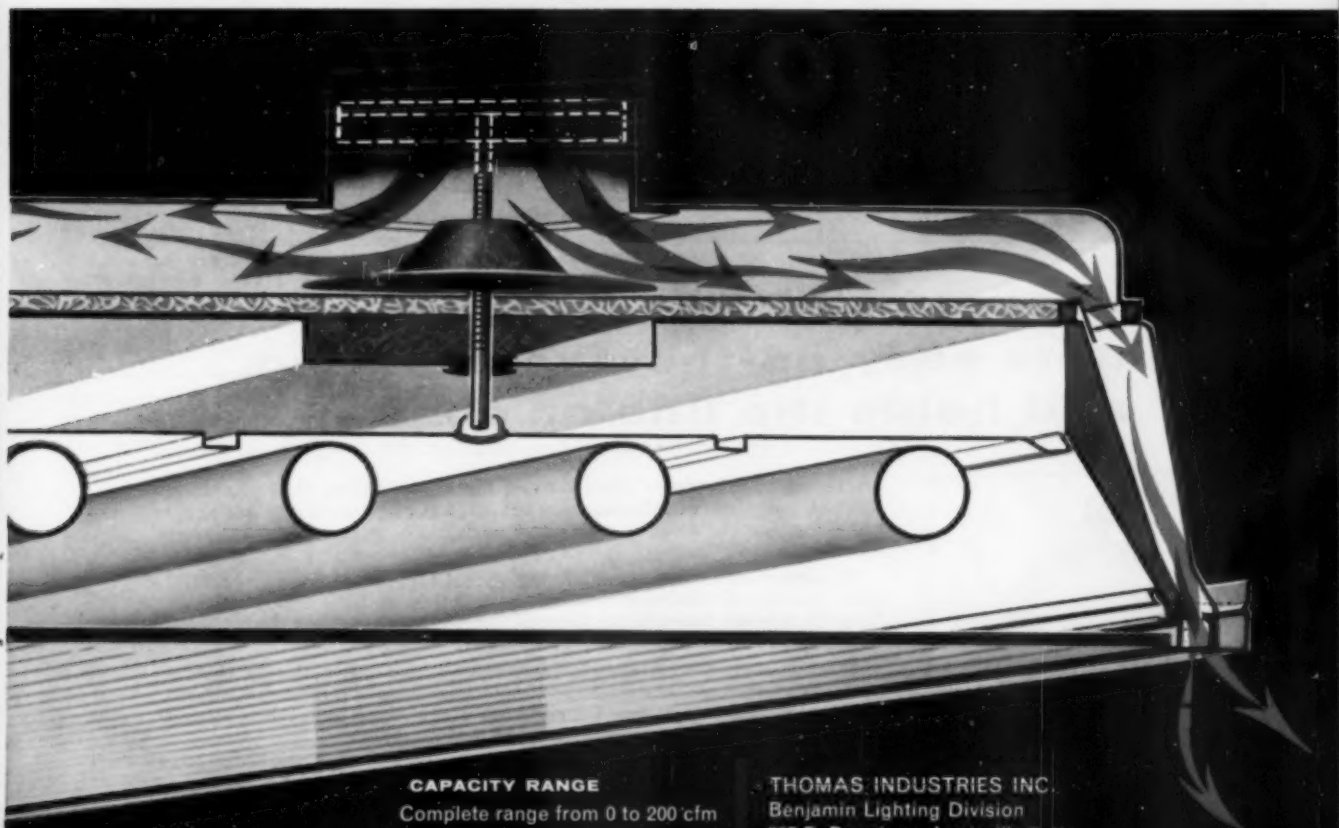
Announcing . . . another big break-through by Benjamin engineering and research . . . a high capacity air-handling troffer that isolates lighting from air flow so effectively that temperature variations cannot affect light output in any way. High lamp efficiency and color is maintained even under the most demanding air handling requirements. And . . . it's all done by means of the amazing new TRIPLE-SHELL construction that completely separates air passages from troffer housing with fiberglas and insulating air spaces.

*Entirely new air diffusing dampers assure super-quiet operation. Air capacities now range from 0 to 200 cfm from a single 1 x 4 or 2 x 4 foot unit.

A new look in trim design features new shallow 4⅞" troffer housing which embodies many distinctive features for faster installation and easier maintenance not found on competitive models. TRIPLE-SHELL Lumi-Flo troffers are available for use with all basic ceiling systems . . . in a wide selection of louvered, glass or plastic closures.

Benjamin, the manufacturer of over 90% of all air-handling troffers now in service, is continually researching new improvements. Its extensive research and development facilities have recently been expanded to include a modern air test laboratory where air and lighting designs can be verified under actual job conditions.

*Air diffusing dampers have been developed especially for Lumi-Flo by **TUTTLE & BAILEY,** foremost design engineers and manufacturers of air distribution equipment.*



CAPACITY RANGE

Complete range from 0 to 200 cfm available in 3 capacities.

LOW . . . 0/80 cfm
MEDIUM . . . 40/120 cfm
HIGH . . . 100/200 cfm

THOMAS INDUSTRIES INC.
Benjamin Lighting Division
207 E. Broadway, Louisville 2, Ky.

- ☐ Please send me complete information on the Lumi-Flo Troffers
- ☐ Please have your representative call

BENJAMIN DIVISION
207 East Broadway, Louisville 2, Kentucky
commerce, industry and home

Dept. BIE-6

NAME _____

FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Niagara-Mohawk Power Corporation, Huntley Station, Buffalo, New York.

Power company selects Abolite...

Gets easy-on-the-eyes lighting, and holds the line on costs

INSTALLATION DATA

Abolite HMFAU-2400 Alzak aluminum uplight fixtures with 1000 watt color-improved mercury lamps. Ceiling height 65', mounting height 55', spacing 18' x 24'. Average maintained footcandle level: 30.

Electrical Contractor: Buffalo Electric Co.

Engineers at this power plant wanted high bay lighting that combined comfort with low installation and maintenance costs. They got it by installing Abolite fixtures equipped with 1000 watt color-improved mercury lamps.

Though these fixtures are mounted 55 feet high, they provide comfortable, glareless 30 footcandle average light throughout the building. Light directed upward through the fixtures' open tops washes out dark ceiling shadows. 35° shielding of lamp virtually eliminates glare.

Most important, this system costs less to buy and maintain than a comparable fluorescent system because fewer fixtures are needed. Maintenance costs are less, too, because air circulating through Abolite's open-top fixtures sweeps them clean of dulling dust.

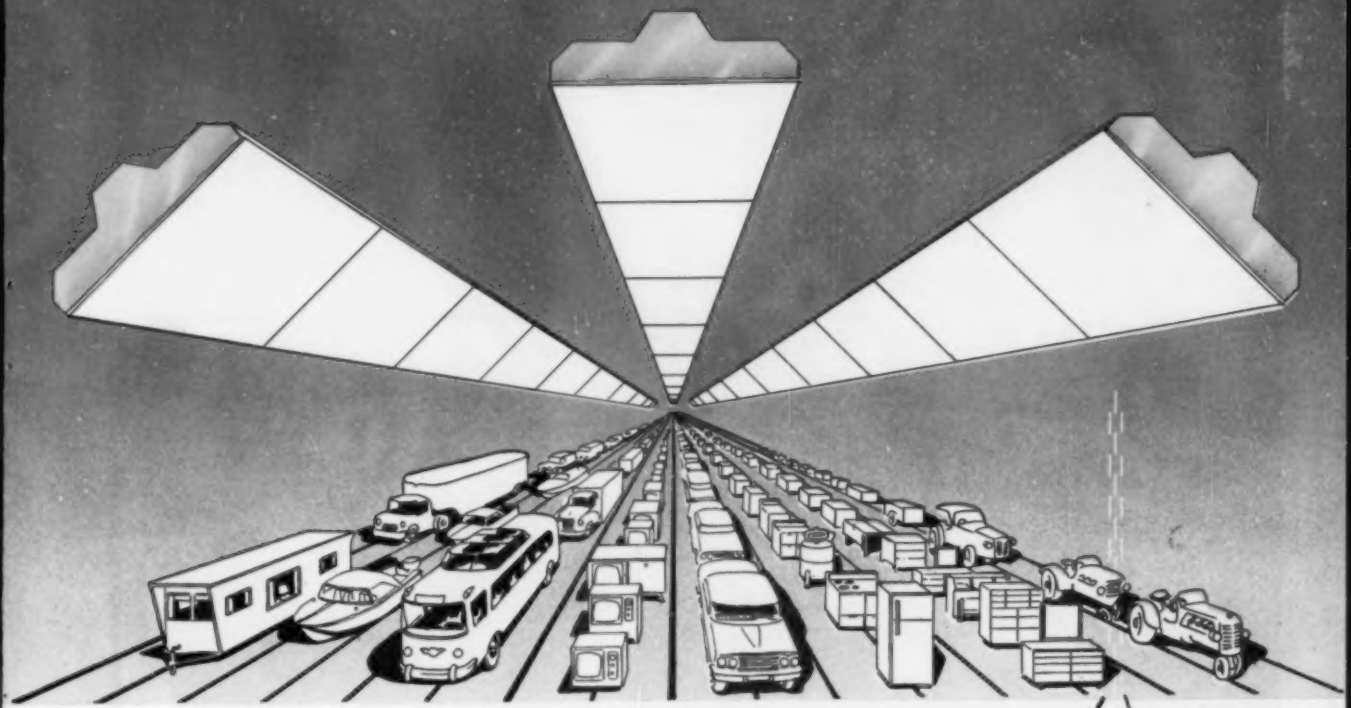
For high bay lighting that combines both comfort *and* economy, specify Abolite fixtures. The complete line includes RLM-approved Alzak aluminum and porcelain enamel fixtures for use with all kinds of mercury and incandescent lamps. Write for more information.

ABOLITE *Lighting*

THE JONES METAL PRODUCTS COMPANY

West Lafayette, Ohio

A new protected lighting fixture for ASSEMBLY LINE LIGHTING

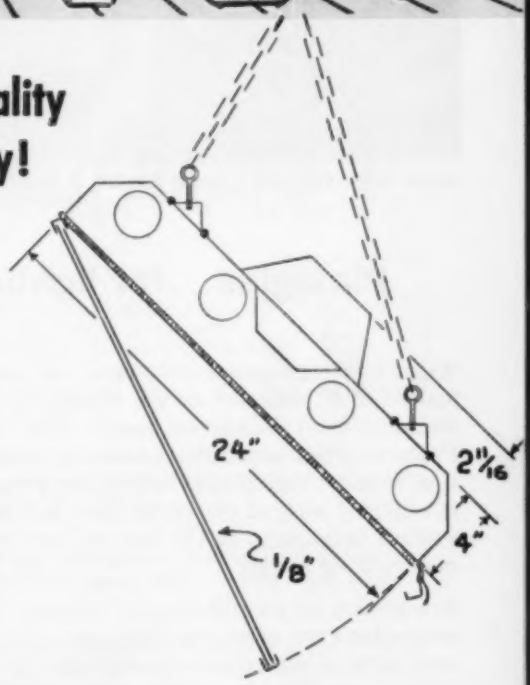


New high-level lighting assures higher quality products and increases production efficiency!

Industry has found that this high-level, high quality lighting is an important factor in increasing the standards of workmanship and greatly reduces the rejections on final inspection of their products. It's common knowledge that adequate lighting also reduces strain and fatigue among workers and contributes greatly to safety and employee morale.

These and many other features found in Paramount quality lighting fixtures are why they pay for themselves quickly.

- **Lighting levels of 500 foot candles readily achieved**
- **Fully gasketed to keep out dirt and dust**
- **Easy access to lamps — hinged shield attached with spring latches**
- **Heavy translucent acrylic shield framed in stainless steel — light, unbreakable and lifts off for cleaning**
- **Separate ballast channel for efficient lamp operation**
- **Versatile — engineered to operate either two or four 1500 Ma lamps**
- **Adaptable for use in continuous rows or specific inspection locations**
- **Conducive to fast rearrangements in assembly line**
- **Approved by Underwriters' Laboratories**



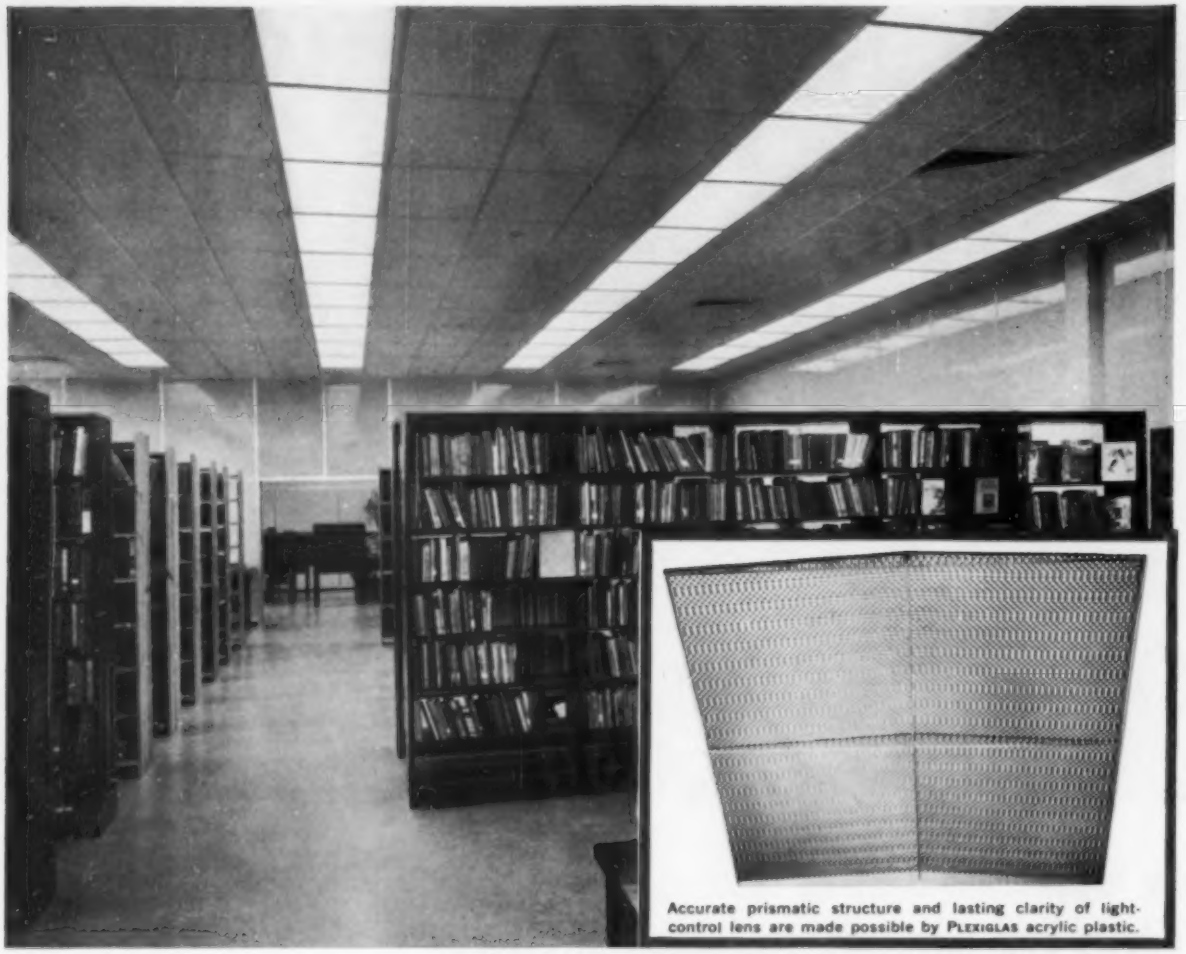
Protected Lighting
CRAFT LITE

DO YOU HAVE A LIGHTING PROBLEM? Paramount engineers stand ready to devote their extensive background in lighting design and development to solve your lighting requirements.

FOR FURTHER INFORMATION — SEE YOUR DISTRIBUTOR OR WRITE DIRECTLY TO —

PARAMOUNT INDUSTRIES, INC.

G-1080 BALLENGER ROAD • FLINT, MICHIGAN • PHONE CEdar 5-6922



Accurate prismatic structure and lasting clarity of light-control lens are made possible by PLEXIGLAS acrylic plastic.

Control lenses molded of PLEXIGLAS mounted in continuous rows in library of County of Sonoma school administration building, Santa Rosa, California. Architects: Steel & Van Dyke, Santa Rosa.

Plexiglas...for lighting that stands out and stands up

When lighting equipment includes control lenses molded of PLEXIGLAS® acrylic plastic, the result is illumination of the highest quality. This is because PLEXIGLAS makes possible a precisely designed optical element that directs light to the area where it is required and, at the same time, minimizes the surface brightness of the lens as seen from normal viewing angles.

In addition, lenses of PLEXIGLAS remain free of discoloration even after years of exposure to fluorescent light. They are strong and rigid yet light in weight, resulting in safety overhead and ease of maintenance. And the crystal clarity of PLEXIGLAS assures full utilization of light.

Full details on the use of PLEXIGLAS as a lighting material are contained in our 40-page technical bulletin "PLEXIGLAS for Lighting". We will be glad to send you a copy.

ROHM & HAAS

PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario*

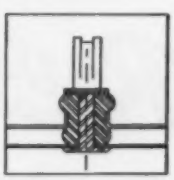
PLEXIGLAS

MULTI-SECTION

BALLAST CAPACITORS

MULTI-SEALED AGAINST LEAKAGE!

There are many reasons why Aerovox Multi-Section AC Ballast Capacitors are now being used by leading ballast manufacturers . . . and by prominent fluorescent and mercury lamp manufacturers. Unmatched leakage protection is one big reason. Check these important points:



1 **Unique terminal construction is time-proven**—your assurance of a positive seal against damaging leakage. Why take chances when experience shows that you can depend on Aerovox AC Ballast Capacitors.

2 **Double-locked seam with sealant** between the cover and the drawn steel container offers maximum protection against impregnant leakage.

3 **Special soldered fill hole** also provides solid leakage protection where it is needed with a solder-to-steel bond.

Send for your FREE copy

of our new AC Ballast Capacitor catalog. Contains technical data on the complete line.

Aerovox Multi-Section AC Ballast Capacitors are available in a wide range of voltages and capacities. Call your local Aerovox representative today for information, or write direct.

AEROVOX CORPORATION

NEW BEDFORD DIVISION **NEW BEDFORD, MASS.**

Technical Leadership – Manufacturing Excellence

No. 560-30-3 No. 115-40-58
RIGID POLES

No. 199-Series
HIGH STRENGTH HINGED POLES

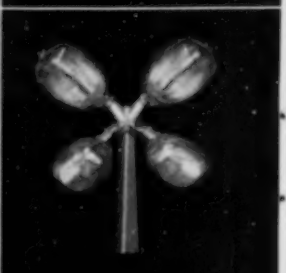
No. 4213-P
ALUMINUM FLOODLIGHT

No. 3807
ELIPTOR FLOODLIGHTS

No. 2001 REAR
SERVICE FLOODLIGHT

No. 4411-P
ECONOMY FLOODLIGHT

No. 5442
ULTRA-LITE



No. 5452
QUAD-OVAL LUMINAIRE

Everything in outdoor lighting equipment from one reliable source

Send for the comprehensive Revere Catalog that lists hundreds of outdoor lighting products, applications and specifications

Revere's 136-page outdoor lighting catalog shows you the industry's widest range of outdoor fluorescent, incandescent and mercury luminaires, as well as poles and accessories. Revere equipment is *design-matched* for best appearance and peak lighting efficiency . . . *structurally-matched* for strength, balance, trouble-free installation and easy maintenance. Write today for your copy of this easy-reference catalog of outdoor lighting equipment.

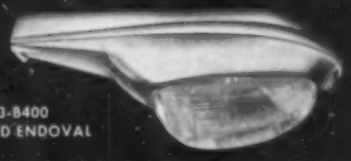
Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NIles 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles

No. 8650 Series
FLUORESIGN LUMINAIRE

No. 9946-V
HIGH LEVEL AREA-LITE

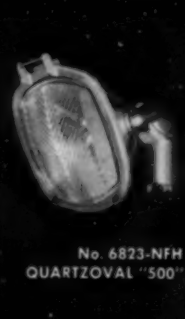


No. 2633-B400
UNITIZED ENDOVAL

No. 2513-B175
UNITIZED URBANOVAL

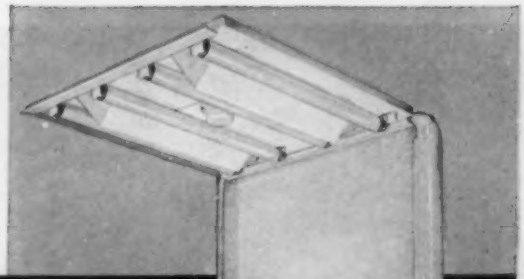
No. 2274
ENDOVAL

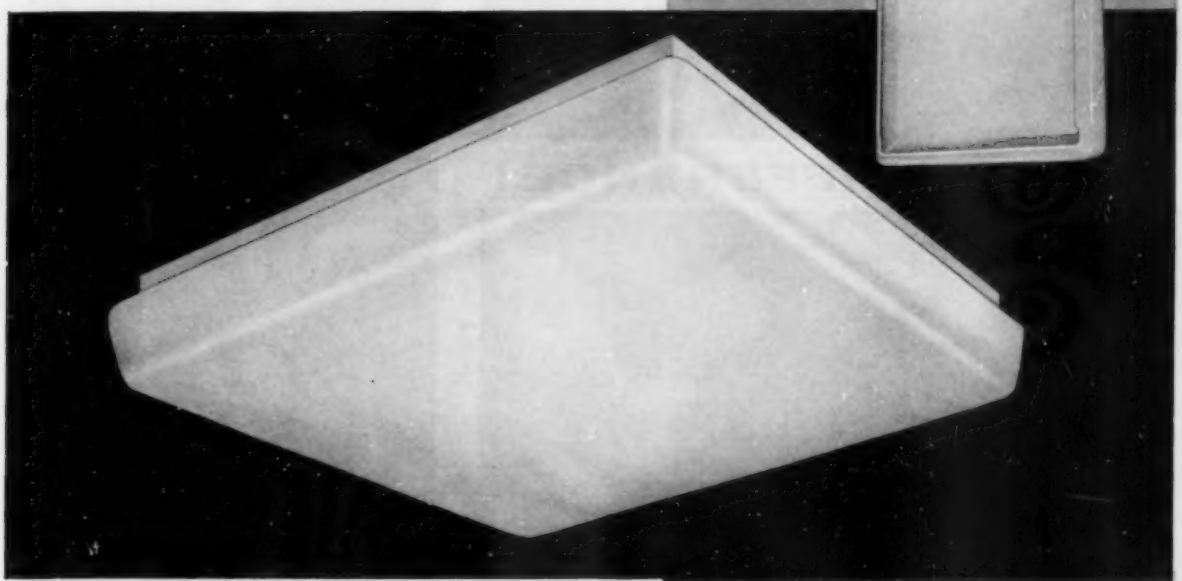
No. 2501-B250
URBANOVAL



No. 6823-NFH
QUARTZOVAL "500"

NEW TWO-BY-TWO SURFACE-MOUNTING LIGHTING FIXTURE





GAR-LITE 909

The latest in lighting for lobbies, corridors, small offices, shops, etc., is new in size, new in style, and new in several important features:

NEW SIZE. The 28" x 28" size is perfect for many areas where large square fixtures or long ones would be out of place. Takes 4 - 20 W, 24" lamps . . . not odd-size or circline lamps as in similar fixtures.

NEW AND UNIQUE DIFFUSER. The shallow (4"), crisply styled diffuser "wraps around" on all four sides. It conceals the chassis in the normal view.

EASY HINGING. The diffuser hinges from either side without latches. Cleaning and re-lamping are quick and easy.

The 909 is fully described in bulletin 61-09. Write, wire or phone for your copy.

DISTRIBUTED EXCLUSIVELY BY GAR-LITE DISTRIBUTORS

GARCY LIGHTING

Div. of Garden City Plating & Mfg. Co.
2475 Elston Avenue • Chicago 47, Ill.

WHAT A DIFFERENCE!

What a beautiful difference

P & K ALL-ALUMINUM LIGHTING STANDARDS

can make in any community

You're looking down Broadway, the main business street of Needles, California. Ordered by the City Council as part of a relighting program, the installation, made by the California-Pacific Utilities Co., consisted of twenty seven P & K 30 foot tapered aluminum lighting standards. As you can see from the photos above, the difference is immediately apparent. The result is greater safety for the community at night and the beautiful modern appearance of the new standards by day. Of course, no painting ever required. Why not write for P & K's new brochure ALS-5 for a wealth of helpful information in your street lighting plans.

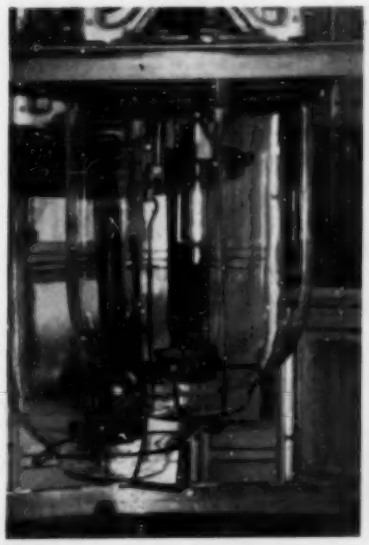
P&K

PFAFF & KENDALL 84 Foundry Street, Newark 5, N. J.

Branch Sales Office: San Jose, California
In Canada: Powerlite Devices LTD., Toronto, Montreal, Vancouver
Export Representative: Philips Export Co., New York, N. Y.

Glass for lighting

A QUICK LOOK AT LIGHTING PROBLEMS ✓ SOLUTIONS ✓ USES ✓



HIGH NOON IN JUNE— TO ORDER ANY TIME

One of our valued customers is in the interesting business of simulating weather conditions. His apparatus is used widely by manufacturers who have to know how their products will stand up to the elements, and have to know in a hurry.

They park a product sample in the Weather-Ometer* and get the results of a full year of natural North Temperate Zone weathering in a mere 300 hours on the average.

The Weather-Ometer uses a violet carbon arc which approximates noon June sunlight (a light source which nature provides very sparingly even in June). Sprays of water, controlled as to temperature, purity, pressure, and volume, wet the specimen to simulate true weathering.

Enclosing the violet carbon arc is a specially designed PYREX® brand glass globe. This glass filters out the short ultraviolet wave lengths, transmits the others to keep the spectrum similar to noon June sunlight and guard the sample against contamination by products of the arc combustion.

A dependable component in an accelerated duplication of nature at work.

*Trademark of Atlas Electric Devices Co., Chicago, Ill.

ECHOES IN THE INFRARED CHANGE A TRAFFIC SIGNAL

A line of cars passes under a compact little unit and—presto—up ahead a traffic signal changes to green.

The unit, fabricated by another ingenious Corning customer,* consists of two devices. One emits a beam of infrared down toward the pavement, via a special glass lens we supplied. The second device receives the echo as a car passes through the infrared beam. The beam bounces back up through another Corning lens, off a silvered glass reflector (ours, too), and onto a cell which activates the unit. The unit then activates the traffic signal or just keeps track of the traffic.

If you happen to spot one of these devices on a drive and *still* have to stop for a red light, do not despair. That sparkling red roundel safeguarding traffic through the intersection is made by us along with the yellow and green ones, all to rigorous specifications.

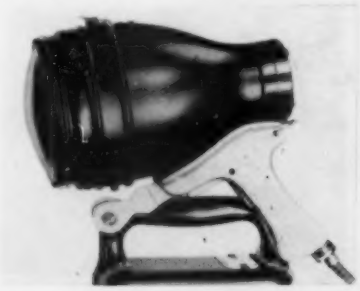
All of which goes to show that we're willing and able to work with you on optical design problems as well as glass design and fabrication.

*Infrared Industries, Waltham, Mass.

THINGS THAT GO GLOW IN THE (APPARENT) DARK

Fluorescence is a happy property of minerals which saves mineralogists many long hours of testing to determine which is which.

It also is a property of many contaminants from which manufacturers like to free their products before they are distributed. Still further, pieces for inspection may be dunked in fluorescent solution and then examined for hairline cracks, etc., which are undesirable.



Fluorescence shows up to best advantage under black light—light from which all but the ultraviolet has been absorbed. Still another of our customers* makes a wide range of black light sources, and we are privileged to help him.

We supply an ultraviolet-transmitting, visible-light-absorbing glass in pressed convex roundels and in tubular form. The roundels are used in mercury lamps, the tubes with fluorescent sources.

Our customer uses this glass in units designed for bench mounting or in units which are handily transportable.

*Black Light Eastern Corp., Port Washington, L.I., N.Y.

OR WHAT HAVE YOU?

Perhaps you have another fish to fry in light transmission or absorption.

We've got other glasses—glasses with extremely good ultraviolet absorption, with extremely good infrared absorption, and, in the other direction, good UV *and* IR transmission.

What are the transmission-absorption factors in your lighting problem? In all probability, we can help. The coupon is a good place to start for more information.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 61-61 Crystal Street, Corning, N.Y.

Please send me the following:

- ☐ Information on ultraviolet-transmitting glasses
- ☐ Information on infrared-transmitting glasses

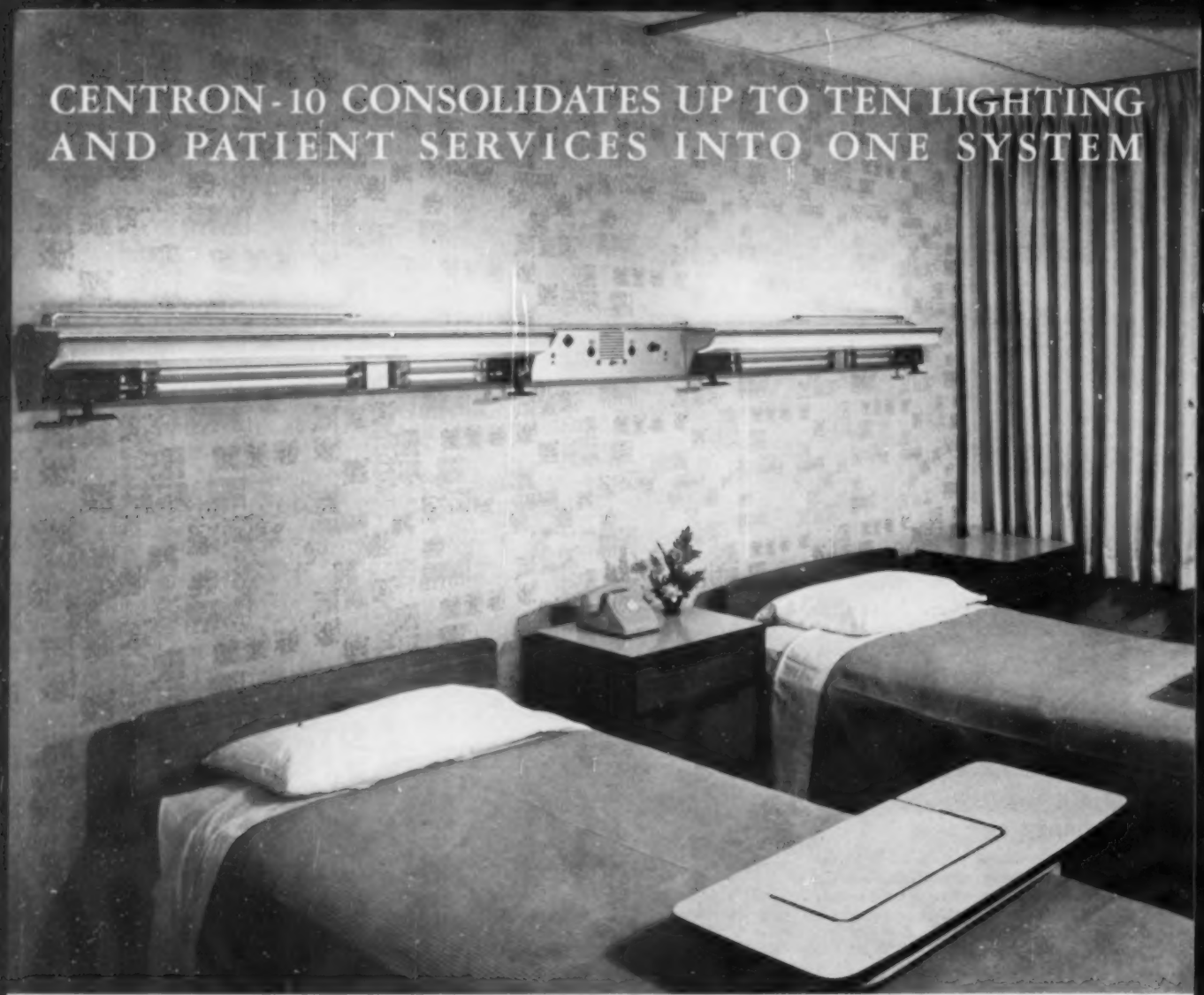
NAME..... TITLE.....

COMPANY.....

ADDRESS.....

CITY..... ZONE..... STATE.....

CENTRON-10 CONSOLIDATES UP TO TEN LIGHTING AND PATIENT SERVICES INTO ONE SYSTEM

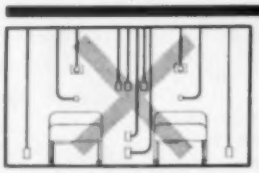


GLARE-FREE GENERAL ILLUMINATION • SHIELDED READING LAMP • HEAT-ABSORBING, COLOR-CORRECTED EXAMINATION LAMP • NIGHT LIGHT • TAKES VARIOUS AUDIO-VISUAL NURSE CALL SYSTEMS • OXYGEN AND VACUUM OUTLETS • TELEPHONE, TELEVISION, RADIO AND CONVENIENCE OUTLETS • INTRA-VENOUS APPARATUS SUPPORT

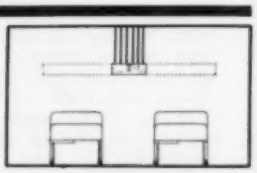
CENTRON-10 brings functional beauty and patient service integration to the hospital bedroom which is particularly appealing to architects, consultants and administrators. The system provides lighting for every seeing task. Softly diffused indirect lighting is pleasant and glare-free. The reading and examination lamps swivel on extendable arms for easy positioning. Centron-10 is adaptable to various nurse-call and oxygen/vacuum systems. It can be installed on any type of wall in new construction or in remodeled interiors. Compact styling and rounded contours help reduce housekeeping costs.

EXAMINATION LAMP, integral with Centron-10, is most convenient.

READING LAMP shielded for minimum disturbance to other patients.



OLD WAY—Up to 11 separately installed outlets clutter each side of the wall.



CENTRON-10 WAY—All service lines consolidated and concealed for clean appearance.

THERE IS NO OTHER SYSTEM LIKE IT!

Centron-10

SUNBEAM LIGHTING COMPANY

777 East 14th Place, Los Angeles 21, California

3840 Georgia Street, Gary, Indiana

Lamps last up to 12 MONTHS MORE

when fixture ballasts wear this emblem!

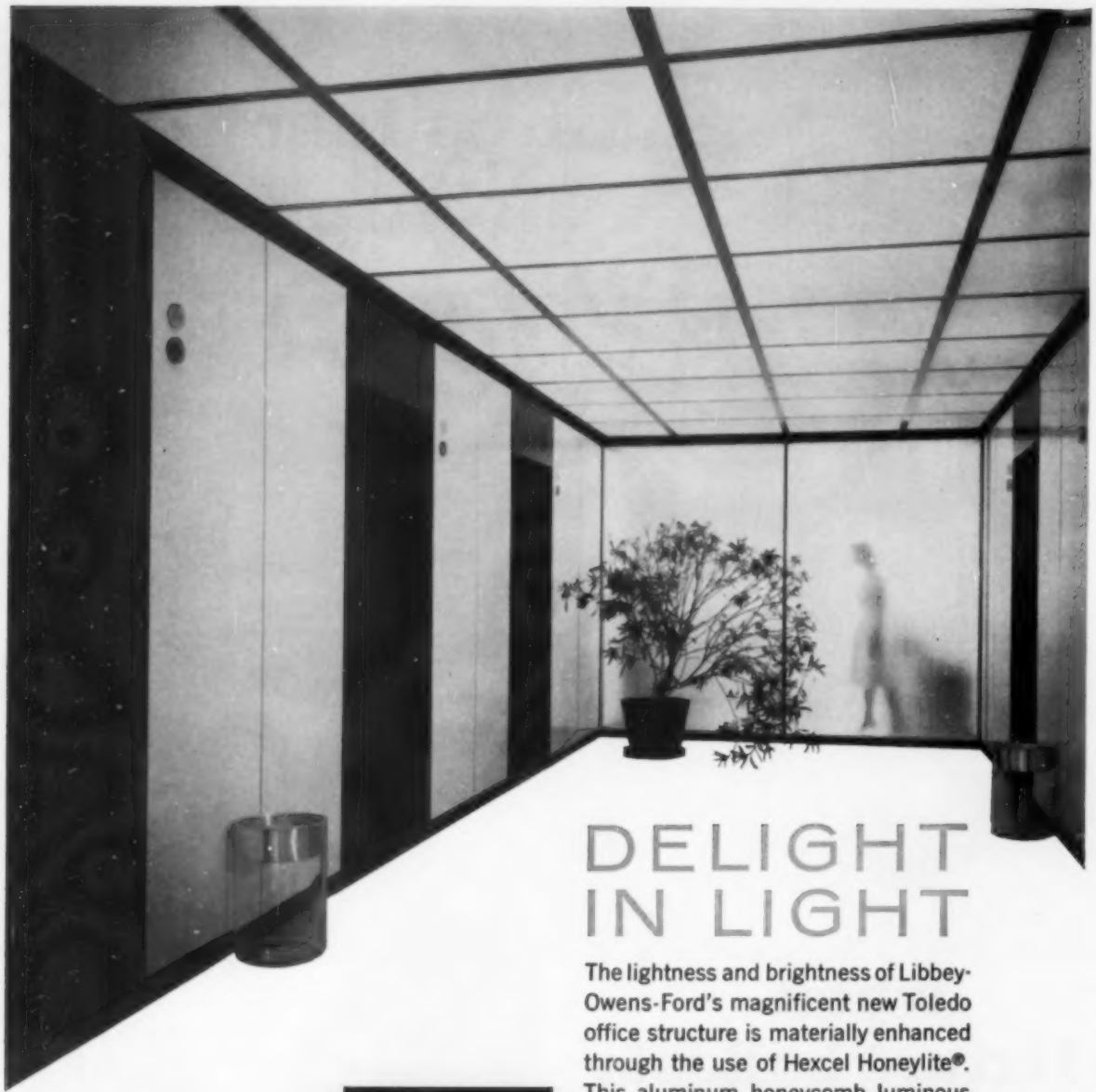
CBM Ballasts are checked by tests regularly, at E.T.L.

It isn't magic . . . it is just that CBM specs assure ballast performance "tailored to the tube" . . . performance that's checked by ETL test. Hence Certified CBM Ballasts can *add* up to 2500 hours more lamp life (equal to 12 months service in one-shift operation). Other practical benefits that grow out of CBM specifications include high light output, positive starting, power factor correction and longer ballast life. And you get UL listing, too! It pays to insist on Certified CBM Ballasts when you specify or install fluorescent fixtures. Want to keep up on ballast developments? Ask us to send you CBM NEWS.

CERTIFIED BALLAST MANUFACTURERS, 2116 Keith Building, Cleveland 15, Ohio.

8-01

Participation in CBM is open to any manufacturer who wishes to qualify.



DELIGHT IN LIGHT

The lightness and brightness of Libbey-Owens-Ford's magnificent new Toledo office structure is materially enhanced through the use of Hexcel Honeylite®. This aluminum honeycomb luminous ceiling system achieves shadow-free, maximum utilization of fluorescent lighting, yet effectively conceals all electrical and mechanical systems. Even air conditioning is installed above the Honeylite panels. All fifteen floors of this installation feature Honeylite ceilings, representing over 120,000 sq. ft. of this totally proven light diffusing system. Owner: Libbey-Owens-Ford, Toledo. Architects: Skidmore, Owings & Merrill. General Contractor: George P. Fuller Company, Electrical Contractor: Rogers Electric, Toledo. For complete Technical Data, send to your nearest Hexcel office.

HEXCEL® PRODUCTS INC.

Stronger, lightweight materials for industry

Executive Offices: *Dept. H-6, 2332 Fourth St., Berkeley 10, Calif.*
Plants: *Berkeley, Oakland, El Segundo, Calif.; Havre de Grace, Md.*
Sales Offices: *Inglewood, Calif.; Fort Worth, Texas; Chicago, Ill.; New York, N.Y.; Havre de Grace, Md.*
Available in Canada through Curtis Lighting, Ltd., Toronto, Ontario

New

CROUSE/HINDS

QUARTZ-beam® FLOODLIGHT

Designed to maintain operating position and thermal level essential for proper self-cleaning of iodine-cycle lamps, QUARTZ-beam QFL-15 projects per-unit-area maximum of lamp's 33,000 lumen output. Provides constant unfading output of clean, white light, with candlepowers up to 200,000, and an average lamp life of 2,000 hours.

Three beam spreads available, with minimum vertical angle as narrow as 13°. Reflector is one piece die-formed, polished or etched. Cast aluminum door and housing sealed by silicone rubber gasket. Heat and impact resisting lens. Door locks tightly and releases quickly by means of 4 wing-nut clamps.

External raintight fuseholder (with fuse). Aiming and leveling device, exterior focusing screws included. Trunnion or slip fitter mounting. Hood, louvers and special mounting bases available. Get further information from your Crouse-Hinds distributor.

concentrates in sharp rectangular patterns the high-lumen output of 1500 watt Quartz-Iodine lamps
Type QFL-15 1500 W.
Ask for Bulletin 2729
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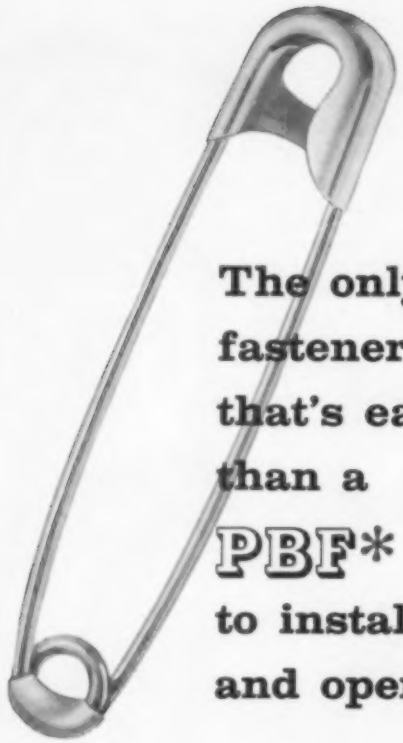

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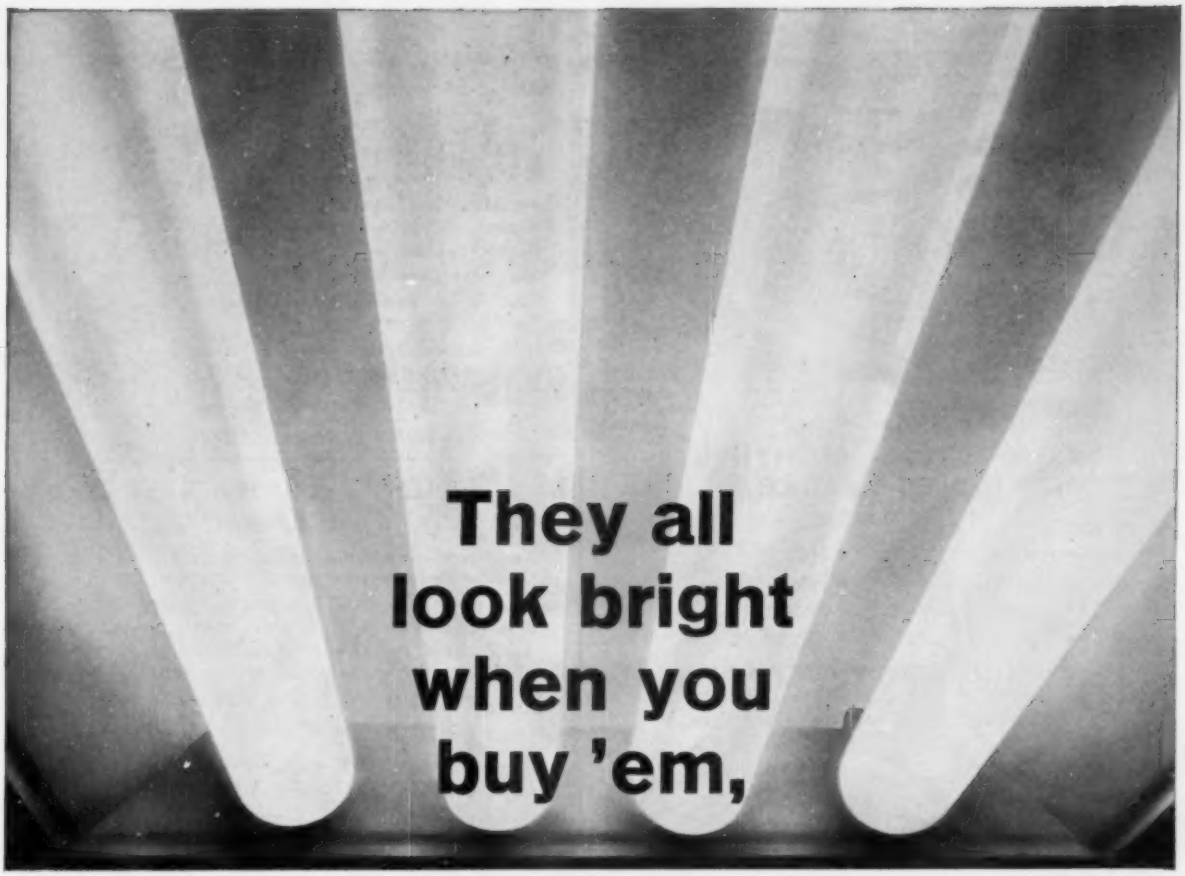

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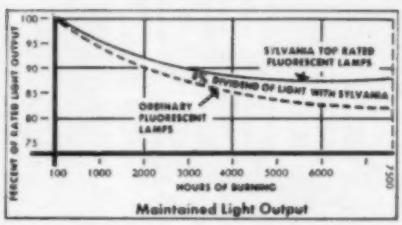

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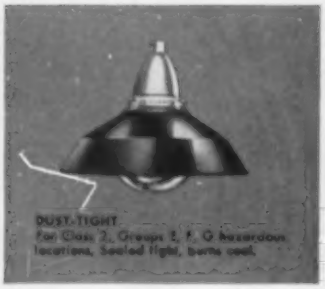

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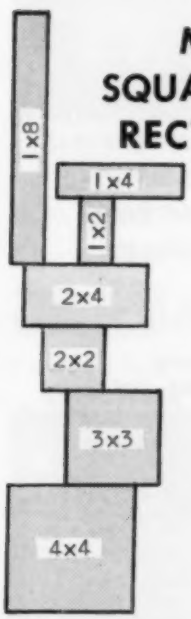

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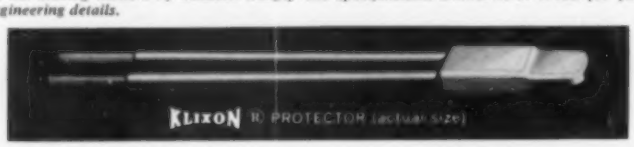
- No dripping compound, fires or violent failures at end of ballast life.

These KLIXON benefits are not attainable with fuse protection. Ballasts under some fault conditions draw less than full rated current, still deliver light, but may have a case temperature twice the allowable U/L limit for normal operation. Thus BALLAST OVERHEAT PROTECTION is a TEMPERATURE, not a CURRENT problem.

Ballasts equipped with KLIXON Protectors can be supplied to your fixture manufacturer by all six leading makers of ballasts. Simply use specifications shown here. Write for full engineering details.



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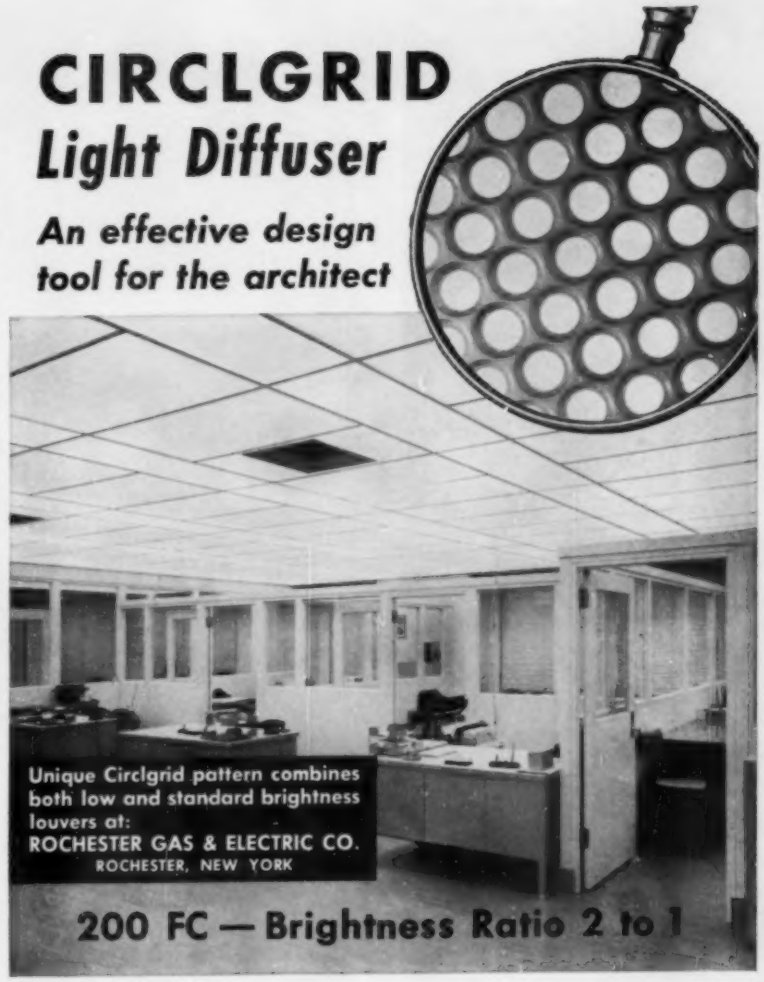
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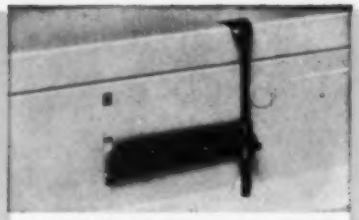

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with NEW SMB swing mounting brackets

New Guth Troffers feature Swing Mounting Brackets to simplify installation...**plus** a complete variety to fit most every specification requirement!

New 4¾" shallow models come in 2' and 4' widths. Other units in 6" and 12" widths . . . 2', 4' and 8' lengths. Almost any bottom you can name — including GrateLite Louver Diffuser** and Prismoid GrateLite†. Adaptable to nearly every type of ceiling suspension system.

*These savings do not include wiring and final connections and are based on installation in a plaster or concealed suspension system.

ASK FOR GUTH SMB TROFFER BULLETINS!

THE EDWIN F. GUTH CO. 2615 WASHINGTON BLVD. • BOX 7079, ST. LOUIS 77, MO.

**U. S. PAT. NO. 2,748,681 CAN. PAT. NO. 530,245 †U. S. PAT. NO. 2,904,673

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